

# Utah Science

---

Volume 41 | Number 3

Article 1

---

9-1980

## Utah Science Vol. 41 No. 3, Fall 1980

Follow this and additional works at: <https://digitalcommons.usu.edu/utscience>

Utah Science is produced by Utah State University Agricultural Experiment Station.

---

### Recommended Citation

(1980) "Utah Science Vol. 41 No. 3, Fall 1980," *Utah Science*: Vol. 41 : No. 3 , Article 1.

Available at: <https://digitalcommons.usu.edu/utscience/vol41/iss3/1>

This Article is brought to you for free and open access by the Journals at DigitalCommons@USU. It has been accepted for inclusion in Utah Science by an authorized administrator of DigitalCommons@USU. For more information, please contact [digitalcommons@usu.edu](mailto:digitalcommons@usu.edu).



# UTAH SCIENCE

UTAH AGRICULTURAL EXPERIMENT STATION FALL 1980 VOLUME 41 NUMBER 3



**SAGEBRUSH REBELLION:**

**Revolution against  
a new colonialism?**



# UTAH SCIENCE

UTAH AGRICULTURAL EXPERIMENT STATION

## 71 TRAMPLING EFFECTS ON RANGELANDS

Gerald F. Gifford and Manouchehr Dadkhah

Protection of topsoil is the key to watershed management. Results show that this can be accomplished with a 50 percent protective ground cover. Degrees of trampling on various ground covers on different soils and slopes are compared.

## 74 SLUDGE—A WASTE OR A RESOURCE?

Raymond W. Miller and Rex S. Spendlove

Long considered unuseable, sewage sludge is being studied for use as a crop fertilizer with definition of its possible consequences and benefits.

## 78 BEETLE KILL IN THE LODGEPOLE PINE

Richard G. Ballard, Michael A. Walsh, and Walter E. Cole

The lodgepole pine beetle does not work alone in destroying western forests. After the beetle bores into the tree, a blue stain fungus present on the beetle invades the tree's trunk and literally plugs its vital pathways.

## 82 THE SAGEBRUSH REBELLION: AN ECONOMIC ANALYSIS

Allen D. LeBaron, E. Bruce Godfrey, and Darwin B. Nielsen

Past federal subsidies to develop the arid West, grazing and mineral developments, and the imbalance in land and financial power between West and East have all contributed to today's Sagebrush Rebellion. Economic feasibility of transferring the lands in question to state administration is analyzed in terms of the rebellion's historical roots.

## 92 SUCROSE VS. FRUCTOSE—IS SUGAR A KEY TO CALORIES?

Charlotte Brennand and Sherrie Hardy

Baking qualities resulting from the two sweeteners were studied in cookies. Crunchier cookies from sucrose, chewier ones from fructose.

## 94 TRENDS IN UTAH'S FRUIT PRODUCTION

Roice H. Anderson

Data gathered statewide indicates that agriculture is moving from diversified to specialized; more fruit is being marketed from fewer acres; and major fruits are now apples, cherries, and peaches. New and expanding markets in the Intermountain West are encouraging this industry.

## 98 FOOD STORAGE: HOW GOOD FOR HOW LONG?

D. K. Salunkhe, S. K. Sathe, and C. A. Ernstrom

Utah State scientists have spent years proving that heat-treated "bagged" foods and freeze-dried compressed foods will ultimately cost us less, retain vitamins better, and last longer. A variety of products comparatively processed are listed with tested results.

### ABOUT THE COVER

The Sagebrush Rebellion, rooted in western history, is being fueled by a rejuvenated desire for independence and self-determination. In the article on page 82, we present an analysis of the economic feasibility of the proposed land transfers as it relates to people and the less readily measured elements of the rebellion.

Cover photograph taken by Carol Grundmann.



A RANGE WATERSHED is generally expected to produce some combination of forage, water, and recreation. Whether such production is at an optimum level depends to a large extent on the type and condition of the topsoil that mantles the watershed. Thus, protection of topsoil automatically becomes a major objective of watershed managers.

Loss or compaction of topsoil can mean premature clogging of reservoirs, poor nutrition for vegetation, lessened ability of the watershed to absorb and hold water, and/or flooding of adjacent, lower-elevation lands. The factors commonly considered crucial in managing topsoil are: soil type, degree of slope, kind and amount of vegetative cover, and the multiple effects of grazing animals (trampling/compaction and vegetation removal/modification).

Our results, from a study completed at USU's Ecology Center facility, indicated that trampling had the most significant effect on water infiltration rates (soil compaction). Sheet erosion (topsoil loss), however, was governed primarily by degree of grass cover. Given the slopes, soils, and other conditions of our work (see below), watershed topsoil can probably be adequately protected by a 50 percent protective ground cover. This is in contrast to previous recommendations that have called for 60 to 75 percent cover. We recommend additional field validation studies to confirm this finding.

#### WAYS AND MEANS

A loam topsoil (42 percent sand, 20 percent clay) was arranged in each of 140 plywood boxes (75 x 70 x 35 centimeters) to provide a uniform 15 percent gradient.

In those boxes, we tested two contrasting grass species, intermediate wheatgrass (*Agropyron intermedium*, a sod-forming grass), and crested

# TRAMPLING EFFECTS ON RANGELAND

GERALD F. GIFFORD  
and  
MANOUCHEHR DADKHAH

wheatgrass (*Agropyron cristatum*, a bunchgrass). These two species were selected because they are commonly used in seeding western rangelands in the United States.

During late May 1976, 60 plots were seeded to each grass. In early fall of the same year, the grass cover on predesignated plots was reduced by uprooting to approximately 30, 50, or 80 percent.

We also wanted to check the effects of five levels of rock cover from zero to 20 percent (with five percent increments) on infiltration rate and sheet erosion. Rock size ranged from five to 10 centimeters in diameter.

Since we obviously could not use grazing animals, we simulated livestock trampling on the study plots with an artificial device. Lull (1959), reported that cattle exert standing loads of about 1.68 kg/cm<sup>2</sup>. This pressure on the soil surface will increase two to four times when animals move. In this study, 2.10 kg/cm<sup>2</sup> was chosen as a compromise loading.

The soil compaction device is a 90 cm by 90 cm metal plate with four legs. The front legs were adjustable to facilitate leveling. At the middle of the metal plate (61 cm x 61 cm) 64 holes (8 x 8 grid) were drilled 7.65 cm apart.

Each hole was fitted with a five cm long square bushing to hold a "foot" (a 30-cm long, square rod with a circular metal plate at one end). The metal plate works as a hoof. The area of each plate (34.4 cm<sup>2</sup>) was approximately 0.925 percent of the effective area (3721 cm<sup>2</sup>) of each plot.

By randomly depressing 11 of the plates, 10 percent of the area of a plot could be compacted. Using all 64 positions would give compaction over approximately 60 percent of a plot. Plate locations (on the 8 x 8 grid) for each 10 percent trampling interval were selected randomly and the same points were not repeated in following intervals. Trampling took place on plots prewet to field capacity.

The infiltrometer we used to measure infiltration rates is illustrated in Figure 1.

Throughout the study, we expended considerable effort to insure that we duplicated natural conditions with our rainfall simulator.

Our procedures have been described in detail in an article scheduled for publication in the Water Resources Bulletin.

#### WHAT WE LEARNED

##### Grass species and infiltration

Plots with sod-forming grass had a higher average infiltration rate than plots with bunchgrass during each 30 minutes of simulated rainfall (Figure 5). This difference in infiltration rates, however, was not particularly significant from a practical standpoint.

##### Trampling and infiltration

Infiltration rates decreased significantly as we increased the trampling percentage (Figure 3). Soil compaction, as it reduces amount and size of surface pore space, adversely affects infiltration rates. Infiltration rates decreased uniformly as trampling



percentages increased, regardless of time intervals or grass cover. This implies that, regardless of grass cover, trampling will decrease water intake rates of loam topsoils.

Infiltration rates decreased most dramatically within the range of zero to 20 percent trampling. When the trampling percentage was less than 40 percent, plots with 80 or 50 percent grass cover always had significantly greater infiltration rates than plots with 30 percent grass cover (Figure 3). But when the trampling percentage equalled or exceeded 40 percent, there were no significant differences in infiltration between plots with 30 or 50 percent grass cover. We therefore concluded that not only does trampling decrease infiltration rates, it also influences the effectiveness of grass cover.

### Grass cover and infiltration

We found no significant differences, regardless of the time interval, between infiltration rates on plots with 50 or 80 percent grass cover (Figure 4). Plots with 30 percent grass cover, however, had the lowest infiltration rates at all levels of trampling. These data strongly imply that the minimum required cover for maximizing infiltration rates on soils and slopes similar to those utilized in this study is approximately 50 percent. Obviously, grazing management options would have a much greater latitude if minimum cover values on slopes of 15 percent or less could be safely maintained at 50 percent rather than 70 percent, a value often cited as the "ideal" by watershed managers.

### Relative importance of trampling, grass cover, and rock cover on infiltration rates

Multiple regression analyses utilizing various combinations of grass cover, rock cover, and trampling indicated that the most important factor influencing infiltration rates was trampling. It explained 35 to 48 percent of the variation associated with infiltration rates as measured at different time intervals. The percent of variation explained by trampling increased with time.

## SHEET EROSION

### Grass cover and sheet erosion

According to our analyses of variance, degree of grass cover was the only factor that influenced sheet erosion. Due to our study design, it was not possible to statistically isolate the effect of trampling on sheet erosion.

At all trampling levels, bare plots had significantly higher erosion than plots with various degrees of grass cover (Table 1). The effects of grass cover on sheet erosion could be categorized as:

- a) bare soils, always associated with high erosion rates.
- b) sparse coverage (about 30 percent), which provided intermediate erosion yields.
- c) high coverage (50 percent or more), which discharged the minimum rate of erosion.

Erosion decreased exponentially as percent of plant coverage increased, regardless of the degree of trampling (Figure 5). But trampling disturbance did increase variability of erosion yields.

As cover increased, the erosion versus vegetal cover curves for differing trampling percentages tended to merge. This visual (nonstatistical) trend may indicate that trampling, up to about 30 percent, had its major impact on sediment yields on bare and sparsely vegetated soil. At 15 to 20 percent or higher plant cover, however, cover exerted dominant control over the sheet erosion process.

### Relative importance of grass cover and rock cover on sheet erosion

Multiple regression analyses revealed that grass cover, as an individual factor, explained 40 to 62 percent of the variation associated with erosion yields at various percentages of trampling. In this experiment, rock cover did not have any significant impact on erosion rates. The percent of variation explained by grass cover decreased as trampling percentage increased. Based on these results, grass cover was of prime importance in determining erosion rates, regardless of trampling percentage.

## SUMMARY

In essence, we found that infiltration rates decreased significantly as trampling rates increased. Also, when trampling equalled or exceeded 40 percent, infiltration rates differed little between plots having 50 or 80 percent cover. At the same time, an infiltration rate could be sustained in uncompacted soils by increasing the vegetative cover while the rock cover was decreased. As compaction due to trampling increased, however, that vegetal-rock cover relationship deteriorated markedly and, at about 20 percent trampling, it disappeared completely.



**FIGURE 1.**  
Soil compaction device used to trample plots.

Our multiple regression analyses of the treatments influencing infiltration rates revealed that trampling explained 35 to 48 percent of the variation. But, regardless of trampling level, bare plots always had significantly higher erosion rates than did plots with various degrees of grass cover. Erosion decreased exponentially as percent plant cover increased. As cover increased beyond perhaps 15 to 20 percent, plant cover dominated control of the sheet erosion process. Also, regardless of trampling percentage, after grass cover reached approximately 50 percent, sediment yields were nearly uniform. Grass cover, as an individual factor, explained 40 to 62 percent of the variation associated with erosion rates at various percentages of trampling.

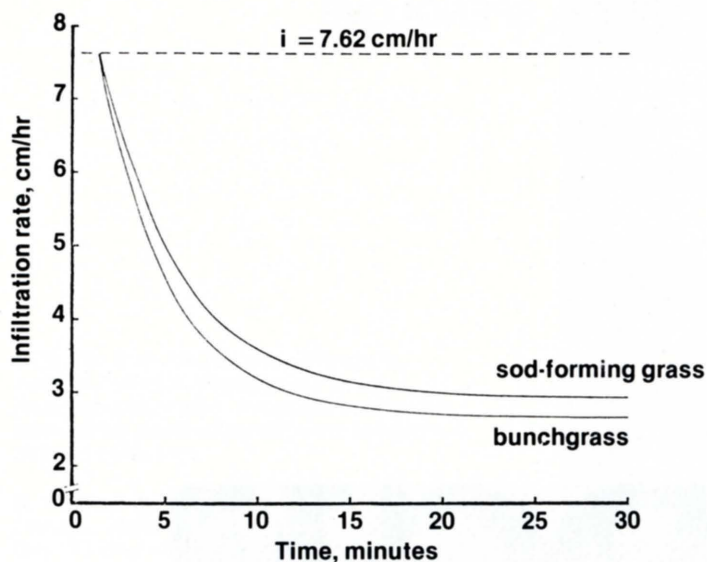
We believe, therefore, that for soils (loam) and slopes (15 percent) as discussed herein, adequate watershed protection may be obtained by maintaining 50 percent protective ground cover. This means that grazing management options are much less constrained than they have been with the currently popular 70 percent ground cover recommendation. Additional field studies are recommended.

### ABOUT THE AUTHORS

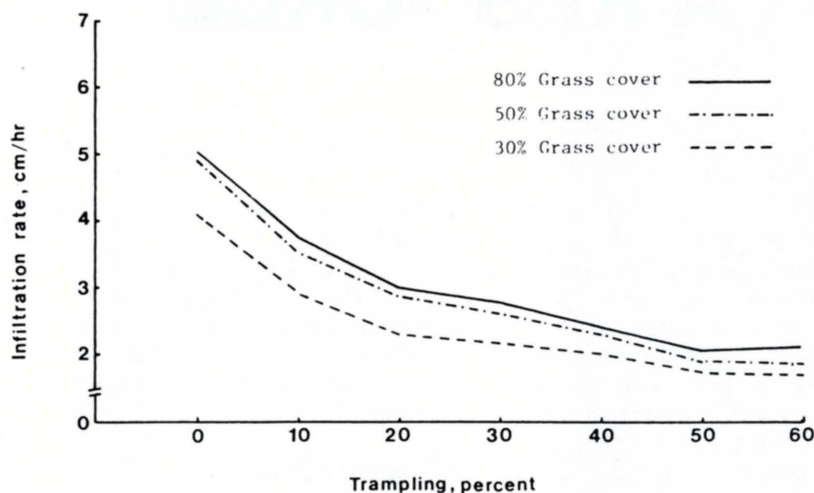
G. F. Gifford is Professor of Rangeland Hydrology and chairman, Watershed Science Unit, College of Natural Resources. He has been a member of the faculty at USU since 1967 and his main interest is the impact on the hydrologic behavior of natural plant communities.

M. Dadkhah recently completed the PhD in Watershed Science and works with the Ministry of Agriculture in Iran.





**FIGURE 2.** Infiltration curves for two contrasting grass species. Differences shown are all significant at .05 level of probability beginning with the 5 minute time interval. Data are pooled over trampling, grass cover, and rock cover treatments.

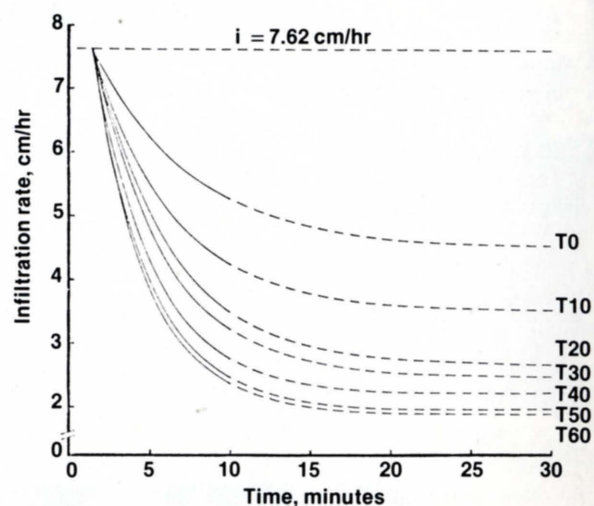


**FIGURE 4.** Infiltration rate as a function of grass cover and trampling disturbance after 30 minutes simulated rainfall. Results are similar for all time intervals after 10 minutes.

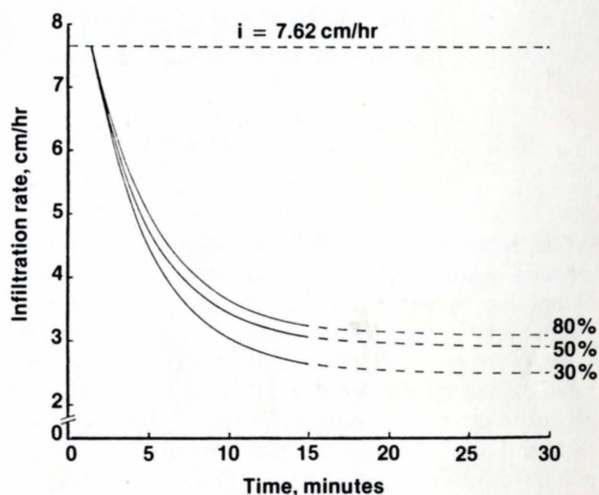
**TABLE 1. Mean comparisons of sediment production (kg/ha) with various percentages of trampling disturbance.<sup>1</sup>**

Trampling Disturbance %	Grass Cover (%)			
	80	50	30	0
0	664.8a	787.9a	1356.8b	6848.9c
10	842.0a	1187.8a	1789.4b	4962.1c
20	840.4a	1138.9a	1568.0b	4583.8c
30	868.5a	1083.9a	1520.5b	3564.8c
40	933.5a	1185.1a	1599.1b	3483.9c
50	987.9a	1317.9ab	1588.2b	3499.5c
60	852.4a	936.0a	1387.1b	3405.3c

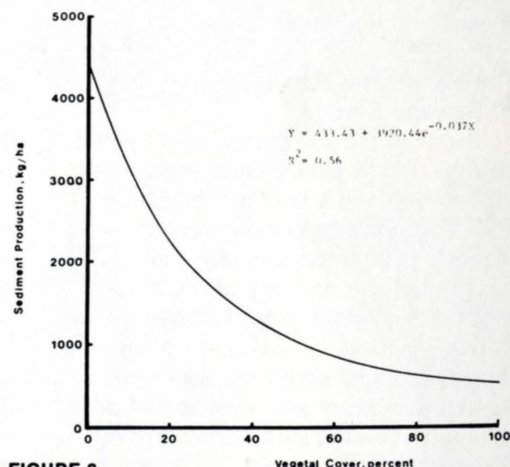
<sup>1</sup>Any two means in the same row with the same lower case subscript are not significantly different at the .05 level of probability. Comparisons among trampling percentages are not possible since the trampling was applied sequentially to each plot in 10% increments, and a given response is biased to an unknown degree by previous trampling and runoff history. Data pooled over grass species and rock cover treatments.



**FIGURE 3.** Infiltration rate curves for different soil compaction treatments. Dotted portions of each curve represent time periods after 10 minutes when an interaction between grass cover and trampling existed. Data pooled over grass species, grass cover, and rock cover treatments.



**FIGURE 5.** Infiltration rate curves for different percentages of grass cover. Dotted portions of each curve represent time periods after 15 minutes when an interaction between grass cover and trampling existed. Data pooled over grass species, trampling, and rock cover treatments.



**FIGURE 6.** Sediment production as a function of vegetative cover, all data pooled.





## A WASTE OR A RESOURCE

WITH INCREASING CONSTRUCTION of sewage systems, the quantity of sewage sludge increases. In the past, many small facilities have given sludge to farmers for fertilizer. Larger systems have dumped it into landfills or composted it (and perhaps added some fertilizer) and sold it as a nursery aid or soil builder. A company has just begun to compost Salt Lake City sludge for retail nursery and garden use. Is sewage sludge beneficial? Can it be harmful?

Should it be used at all?

These are concerns which this article should help the reader answer.

### The Whats and Hows of Sewage Sludge

Sludge is the solid remains of treated sewage. It will usually have undergone chlorination and a period of digestion. The most common product ready for disposal is anaerobically digested sludge, but it is only one of the many kinds of sludges that exist (Table 1).

The benefits from using sludge as fertilizer include improving the physical condition of a soil and its supply of plant nutrients. Sewage sludge may be over 65 percent organic materials, which help aerate the soil and improve water movement through it. The sludge also

contains usable nutrients for plants (see Table 2). In comparison to animal manures, sludge often supplies substantial quantities of phosphorus.

Resistance to using sludges as fertilizer and regulations against its general distribution are mostly based on a fear of spreading disease organisms and/or possibly increasing quantities of heavy metals in the animal food chain. Pathogens that may persist in sludge include the four basic groups: (1) bacteria, (2) helminths, (3) protozoans, and (4) viruses. Although some intestinal bacteria are pathogenic, the majority in sewage sludge are not hazardous. The coliforms and fecal streptococci serve as indicators of environmental contamination by fecal materials. Pathogenic bacteria may survive for days or weeks in soils.

Helminth parasites (roundworm, hookworm, tapeworm) survive in sludge under many conditions. Roundworm eggs (oval), which can be found in almost any sewage sludge, are able to survive long periods of exposure in either soil or sludge. High temperatures are usually needed to kill these eggs.

Disease-causing protozoans cause intestinal track disorders of varying magnitudes. Although a protozoan cannot live outside its host, protozoan

cyst forms do survive days and weeks in soil systems.

Many kinds of viruses exist in sludges. The exact extent of the problem has been masked because reliable laboratory methods for identifying active viruses have not been available.

### A Brighter Future

Several things make the future use of sewage sludge on cropland probable and even quite desirable. First, existing EPA regulations will gradually reduce the quantities of metals that industries dump into sewage systems. Within several years' time, therefore, sewage sludge should be a better quality material lower in metal content. Second, disease problems can be largely eliminated by any of several methods: (1) composting, during which the decomposition activity in the sludge causes heating to 55 or 60°C (131 or 140°F) for several weeks, (2) radioactive irradiation, or (3) high temperature heating for minutes or hours. Third, land available for sanitary landfills is not unlimited; something must be done, preferably something useful, with the increasing quantities of sludges and other solid wastes that must be eliminated.



**A.** Sludge from metropolitan Chicago is weighed before it is applied to the soil. Researchers compare the amounts of metals taken up by plants under different soil and climatic conditions.

**B.** Weighed portions of sewage sludges from Chicago, Idaho Falls, Salt Lake City, and Davis County are spread on field plots and mixed into the soil with a roto-tiller prior to planting. Comparisons are made to plots without sludges and between different rates of sludge addition.

**C.** Uptake of problem metals, particularly cadmium and zinc, by spring barley, sudangrass, Swiss chard, and potatoes are measured on these crops from the five sludge materials and under different irrigation rates.

**Table 1. Common types of sewage sludges.**

**Raw sludge:**

Sludge recently separated from the liquid portion (called the effluent) and susceptible to rapid chemical changes by decomposition and drying.

**Anaerobically digested sludge:**

Sludge allowed to undergo decomposition without much aeration (free oxygen) for usually several weeks.

**Aerobically digested sludge:**

Sludge allowed to decompose with good aeration for many days or a few weeks.

**Composted sludge:**

Any sludge which is piled to allow further decomposition to occur.

**Stabilized sludge:**

Any sludge allowed to decompose long enough to lose much of its easily volatile portions; often 40 to 50 percent of the "volatiles" must be removed as an indication of extensive decomposition which normally reduced disease vectors considerably.

Utah's conditions favor using sludges on its croplands. Most Utah soils are alkaline and/or calcareous. The heavy metal uptake by plants and metal

**A**



**B**



**C**





mobility in the soil are less in alkaline than in acidic soils. Heavy metal uptakes are least hazardous when the edible portion of the plant is a grain or fruit. In Utah, the greatest hazards would occur in crops such as leaf greens, dairy forage, and vegetables such as radishes, potatoes, carrots, and beets.

The heavy metal of most concern is cadmium. Although it isn't more toxic to humans than the other metals, cadmium is generally more mobile in soils and plants than the other metals of concern—lead, mercury, zinc, chromium, copper, nickel, and arsenic. All of these metals can accumulate in animals through the foods they eat. In large enough accumulations, the metals may cause problems ranging from dizziness, decreased muscular coordination, reduced vision, and loss of some memory to the extreme toxicity effects of blindness, fragile bones, loss of mental capacities, no muscular control, or death.

## Regulations and Guidelines

Regulatory organizations such as the Environmental Protection Agency (EPA) and state organizations have to regulate uses of sewage sludge materials and they must be assured of health safety factors. The safety of concentration levels of the sludge components has been difficult to verify. Laboratory tests with which to monitor most of the problem viruses have been unavailable. Safe concentrations of heavy metals in foods are only approximately defined, and many factors (kind of soil, kind of crop, part of crop, climate) influence the amount of a metal that can move from sludge into people through the food they eat. Some restrictions and recommendations in present use (EPA guidelines and/or proposed state regulations in California and Colorado) include the following:

1. Any food in commerce grown on sludge-treated soil must not exceed the average value found in similar foods in that marketplace for any poisonous or deleterious substance the product contains (California).
2. The deed for any land which was previously treated with sewage sludge shall state that any future agricultural use of the land must fit regulations for sludge-treated soils (California).

3. Without a user's permit, sludge shall not be applied to soils used to grow foods for producing milk or to be eaten raw by humans (root crops, lettuce) unless the sludge has been piled on-site for over a year before use (Colorado).
4. No user permit is required if sludge is applied: on land with slopes less than five percent (low erosion), on soils more claylike than sandy loam textures, at least 150 feet from a domestic well, to land outside the 10-year flood plain, to land with annual groundwater levels deeper than seven feet, or on soils not saturated or ponded with water (Colorado).
5. No user permit is required for correct usage of sludge containing less than these amounts of metals or polychlorinated biphenyls (PCBs) (Colorado):

3,000 ppm	zinc	1,000 ppm	nickel
1,500 ppm	copper	30 ppm	cadmium
1,500 ppm	lead	10 ppm	PCBs

6. All three regulatory lists (EPA, California, Colorado) discourage the use of sewage sludge on home vegetable gardens. The California regulations state that no sewage sludge has a low enough concentration of cadmium to make it acceptable for home vegetable garden use.
7. Cadmium added yearly to the land in the sludge shall not exceed: 2.0 kg/ha (1.78 lb/a) until the end of 1981  
1.25 kg/ha (1.11 lb/a) in 1982 to 1985  
1.5 kg/ha (0.446 lb/a) after 1985
8. The maximum cumulative amount of total additions of cadmium is not to exceed about 20 kg/ha (17.8 lb/a) on average soils. Only a fourth of this amount is permitted on sand soils.

Utah is establishing regulations for the use of sludges, and is looking to these and other regulations as patterns. Some individuals who encourage the recycling of sludge to enhance plant growth believe many of the restrictions such as those just listed are too severe. Unfortunately, there is yet no proof. Concerned scientists can only make educated approximations of conditions or concentrations that may be hazardous.

## Looking for Answers

A concerted effort is being made to collect information to help make well-founded regulations. Scientists in the 11 western states and 10 north-central states are cooperating on a five-year research program in which sludges are added to many kinds of soils to determine the mobility of the problem metals, the uptake of metals by selected crops, the extent of potential disease problems, and the beneficial effects derived from the use of sludge. In Utah, these studies have been in progress for two years. Every collaborator uses a sludge from Chicago; the Utah State University group also uses sludges from the Idaho Falls Plant, from the South Davis County North and South Plants, and from the Salt Lake County Plant No. 1. Heavy metal contents for these are given in Table 3. Looking just at heavy metal contents and using the proposed criteria given in item 5 of the previous section, the Salt Lake sludge was too high in copper, cadmium, and zinc for use without a user permit. The sludge least contaminated with heavy metals was from Idaho Falls; the material highest in metals was that from Chicago.

At common addition rates (animal manures are spread at rates of 20 to 40 mT/ha or about 9 to 18 tons/a), a farmer could use up to 30 metric tons of Salt Lake City sludge but only about 12 tons of the South Davis North Plant sludge yearly without exceeding allowable annual cadmium addition levels. This permissible addition rate would have to drop to two-thirds this amount by 1982 and to one-fourth this amount by 1986. Total permissible cadmium loading, after which no more sludge could be used ever on that soil, would be reached in about 25 years (by the year 2010). These projections are based upon the Salt Lake City sludge added at 16 metric tons/ha per year (about 7.1 tons/a).

Within a few years, both the disease and the heavy metals problems should be reduced. The beneficial phosphorus and nitrogen contents should then encourage extensive use of sewage sludges as a soil amendment and fertilizer for croplands. Sludge can already be used to good advantage on land producing flowers and non-food plants.

Because disease hazards mostly depend upon the numbers of organisms to which a person may be exposed,



stabilized sludges as now in use probably constitute a minimal health hazard. Problems with heavy metals, however, increase with dosage and time. If used at reasonable rates (2 to 20 metric tons/ha, or 1 to 9 tons/a), most sludges would not likely produce toxicity symptoms in plants or food consumers for decades. Ironically, it is the fear of the *unknown* hazard from possible metal accumulations that prompt officials to impose regulations concerning sludge use that are more strict than is believed necessary by some. Short-term applications should not pose problems to the users, but sludge-treated soil, if later used carelessly in food production, could lead to chronic toxicity levels of heavy metals in persons consuming those food crops over several decades.

### Using Sludges Today

Per dry metric ton, sludge carries about 20 kilograms (44 pounds) of phosphorus and an equal amount of nitrogen. Studies indicate that about 40 to 50 percent of the sludge applied as fertilizer may be decomposed the first year, thereby releasing approximately 40 percent of its nitrogen and phosphorus. That amounts to about 10 to 15 kilograms (22 to 33 pounds) of nitrogen and 7 to 10 kilograms (15 to 22 pounds) of phosphorus per ton of sludge. Some of these released nutrients are reused by bacteria or lost through other processes in the soil before vegetation can use them. Because much less phosphorus than nitrogen is needed by crops, sewage sludge is particularly good as a phosphorus fertilizer, even at low addition rates of 10 metric tons/ha (4.5 tons/a or 20 pounds/100 ft<sup>2</sup>). Supplemental nitrogen would usually be required for high nitrogen users (corn, potatoes, grass pastures, or irrigated grains).



**TABLE 2. Composition of sewage sludges taken from over 200 municipalities in 8 states**

Component	Concentration in dry material			Average pounds per dry ton
	Minimum	Maximum	Median	
—Percent by weight—				lbs/ton
Organic matter	11	83	52	1,048
Total nitrogen	0.1	17.6	3.3	66
Total phosphorus	0.1	14.3	2.3	46
Total potassium	0.02	2.6	0.3	6
Total sulfur	0.6	1.5	1.1	22
—Parts per million—				
Total zinc	101	27,800	1,740	3.5
Total copper	84	10,400	850	1.7
Total chromium	10	99,000	890	1.8
Total cadmium	3	3,410	260	0.5
Total mercury	1	10,600	5	0.01
Total lead	13	19,730	500	1.0

Selected data from L.E. Sommers, "Chemical composition of sewage sludges and analysis of their potential use as fertilizers," *J. Envir. Qual.* 6:225-232 (1977).

**TABLE 3. Heavy metal contents in various sludges, compared to recommended guidelines for addition to soils, and nitrogen and phosphorus contents, based on dry weights.**

Metal	Maximum content permitted in sludge	Sludge Origin 1978-9				
		Chicago	Salt No. 1	South Davis Co.		Idaho Falls
				North	South	
	—ppm*—					
Cadmium	30	225	64	154	11	7
Copper	800-1,500	1,330	1,925	653	875	355
Lead	1,000-1,500	1,070	992	263	281	220
Nickel	100-1,000	528	141	220	53	25
Zinc	3,000-2,000	4,680	3,765	1,220	1,950	1,260
				—%—		
Total nitrogen	—	1.7	2.4	1.9	2.5	1.6
Total phosphorus	—	1.1	2.3	1.8	2.0	2.0

\*Chaney (1973) and Colorado guidelines.

### ABOUT THE AUTHORS

Raymond W. Miller, Professor of Soil Chemistry and Fertility, has been involved in several projects relating to problems of wastes and the environment, including: lead accumulation in the Tooele, Utah area; drilling mud disposal; sewage effluent use on lands; and beneficial use of sewage sludges on crops.

Rex S. Spendlove is Professor of Biology at USU, with interests in environmental virology and viral gastroenteritis.



RICHARD G. BALLARD, MICHAEL A. WALSH,  
and WALTER E. COLE

VACATIONERS IN NATIONAL FORESTS of the western United States (Figure 1) now routinely see thousands of lodgepole pines standing as mausoleums of death (Figure 2). The beetle that is responsible for the devastation is called the mountain pine beetle (*Dendroctonus ponderosae* Hopk.) (Figure 3).

**Figure 1.** Tree in Cache National Forest killed because of mountain pine beetle infestation and/or blue-stain fungi infection. Beetles prefer large healthy trees with thick bark.

**Figure 2.** Research site at head of Logan Canyon near Swan Flat Road. Six 24 inch diameter trees in this area serve as experimental organisms in a cooperative (contractual agreement) study involving researchers at the Plant Anatomy Research Labs at Utah State University and the USDA Forest Service in Ogden, Utah.

**Figure 3.** Adult beetle (*Dendroctonus ponderosae* Hopk.). Average beetles measure 5 mm in length. Beetle shown was probably chewing its way out of a pupal chamber. During this process, fungal spores adhere to beetle body and mouth parts and are carried to new trees where they become inoculated.

**Figure 4.** Bark of previously infested lodgepole pine (*Pinus contorta*). Note holes where beetles make exit and fly to new uninfested trees.

**Figure 5.** Trees where beetles bored into bark causing "pitch tubes." Boring action of beetle causes release of resin from canals in the bark and wood. Sometimes beetles are entrapped in resin, so that pitch tube formation possibly represents a defense mechanism.

**Figure 6.** Bark removed to show beetle galleries. Egg galleries are formed vertically and larval galleries around the circumference of tree. Gallery formation can have a girdling effect on inner bark (phloem) and thus downward flow of sugars is interrupted.

**Figure 7.** Healthy trees are "baited" using special insect attractant called pheromone. Chemical is introduced into "tygon" tubing wrapped around tree. Red area represents previous sampling site. Paint helps identify tree and protects tree. White area is where bark has been removed and xylem is currently being sampled for comparison with tissue sampled after attack.

**Figure 8.** Segment of fungal infected tree. Outer blue-black discoloration (hence the name blue-stain fungi) represents sap-wood where blue-stain fungi have grown and caused an enzymatic degradation of phenolic substances to occur. This is the area of wood involved with water conduction. If blockage resulted because of extensive hyphal development, tree would soon die.

**Figures 9-12.** Procedure used in sampling tissue. **9.** Broad chisel used to rapidly extract large tissue segments. **10.** Bark is pulled back and wood (xylem) is exposed. **11.** Electron microscopy on normal and infected tissue requires tissue be cut into small segments to facilitate rapid killing and fixation. **12.** Tissue is taken to nearby field laboratory operations. Graduate student researcher, Richard Ballard, prepares tissue samples for microscopical analysis. Further processing takes place at Plant Anatomy Research Labs.

IN THE LODGEPOLE PINE









The mountain pine beetle and the lodgepole pine (*Pinus contorta* Douglas var. *latifolia* Engelm.) have evolved an unprecedented relationship over eons of time. Despite all our information about the insect, its life history, preference for *P. contorta* and dynamics of attack, little can be done *directly* to save vigorous pine specimens from devastation. Forest management strategies to prevent and/or minimize these losses are now being tested over varied situations with some success.

### Beetle Biology

Each year around the last week in July, young adult beetles (Figure 3) chew their way out of trees (Figure 4) that were attacked the previous year. They fly to other healthy, uninfested trees where they begin boring into the bark (Figure 5). Here they mate, beginning the next year's generation of beetles. Female beetles bore vertical tunnels called egg galleries (Figure 6) into the inner bark (phloem). The eggs deposited on alternate sides of the tunnel soon hatch, and first instar larvae begin their own feeding activities by chewing horizontal larval galleries around the circumference of the trunk.

As they work, the adult beetles bring the blue stain fungi into the tree with them and thus inoculate the tree. These blue stain fungi include possibly three species of *Europhium* and at least three species of *Ceratocystis*: *C. montia*, *C. minuta*, and *C. minor* isolated from, or associated with, mountain pine beetle attacks. The *Ceratocystis* fungi are similar to fungi associated with Dutch Elm Disease and a disease of pines in the southeastern United States. Because the fungi are consistently observed in association with the beetles, it is presumed a mutualistic relationship exists.

### Local Research Scene

How the fungi function in the deaths of lodgepole pines is of major concern to investigators at the Plant Anatomy Research Laboratories of Utah State University. A research site has been established at the head of Logan Canyon (Figure 1) and cooperative study is underway with scientists at the USDA-Forest Service in Ogden, Utah.

To facilitate study, beetles are attracted to designated trees by using a "bait." Tygon tubing, impregnated with an attractant chemical (pheromone) is tied to selected trees (Figure 7). After

beetles attack a tree, tissues obtained from the tree are subjected to preliminary treatment at the study site (Figures 9-12). They are then transported to the laboratory for further processing and microscopical analysis.

Following beetle infestation of a tree, fungal hyphae grow into the sapwood via living cells of the wood rays (Figures 16 and 17). The "blue-stain" discoloration of the sapwood (Figure 8) is caused by a metabolic by-product of fungal enzyme action on phenolic substances of host tissue. The stain marks the limits of inward fungal growth. The blue stained wood is rendered nonfunctional and as discoloration proceeds inward toward the pith, the tree shows signs of increased stress until finally its transpiration stream is totally disrupted and the tree dies.

### A Fungus Among Us

It has been reported that the fungi are confined to living cells of the wood, namely the ray parenchyma cells (Figures 16 and 17). In our laboratory, however, we have obtained evidence (Figures 18 and 19) that the growth and distribution of fungal hyphae are greater than reported, especially in tissues attacked the previous year. This is especially significant because trees do not succumb until spring or early summer in the year following a beetle attack. Upon close inspection, we have seen hyphae throughout axial water conducting cells (tracheids) of the xylem (Figures 18 and 19). In many cases, the hyphae have occluded the bordered pits (Figure 19) through which water must pass in its ascent up the tree. In short, the fungi plug the tree's plumbing.

Such physical blockage, however, may only account for part of the observed disruption of water flow and subsequent tree death. For example, hyphal growth may affect resin ducts and induce a release of resins and gums into the water conducting pathway. Fungal spores and large molecules may also occlude bordered pits to some extent.

It is also possible that ray parenchyma cells, which are destroyed by the fungi, are somehow essential to normal sap ascent. Uninfested pine trees store great quantities of chemical energy in living ray cells. The energy (sugar) is mobilized in the spring and is essential to renewed growth each year. If the tree is deprived of this material by the fungus, it would certainly be weakened and hence susceptible to stress for

other reasons. We have also wondered if structures called tyloses (wall ingrowths of neighboring parenchyma cells) are formed because of blue stain fungi. Potentially damaging embolisms or tiny gas bubbles in tracheids might be associated with fungi respiration. Also, production of toxin(s) by the fungi cannot be discounted. And finally, one cannot overemphasize the devastating effect of phloem girdling by beetles. This not only increases the potential for water loss, but also interrupts the flow of sugars to roots. In other words, we are still groping among unknowns that must be solved.

### Future Prospects

Since the beetle is the indispensable vector in fungal inoculation, numerous attempts have been made to control the insect. Spraying, clear cutting, selective harvesting, burning, and even breeding programs have been implemented. However, successes have been only occasional, mainly due to environmental variables, the vastness of the area occupied by susceptible trees, the short time when beetles are vulnerable, and the total numbers of trees involved. Although one population of beetles can sometimes be eliminated, the trees remain highly susceptible to a new invasion.

In our laboratory, we are seeking data that will relate the physiological events of increased water stress to temporal aspects of radial growth of fungi into host trees. Our continuing studies of the seasonal development of xylem and phloem in lodgepole pines should help clarify fungal growth and development processes. We are now fairly sure of how to answer the question, "What's killing the lodgepole pines?" Now we must define the mechanism that actually causes death. Only then can we hope to stop the devastation.

### ABOUT THE AUTHORS

Richard G. Ballard is a graduate student in the Biology Department. Mr. Ballard's training is primarily in botany, specializing in anatomy, microbiology, and mycology.

Michael A. Walsh is Assistant Professor of Biology/Botany and Director of the Plant Anatomy Research Laboratory at Utah State University. Dr. Walsh's training has been in plant anatomy, plant ultrastructure, microscopy, and plant cyto-histochemistry.

Walter E. Cole is Project Leader, Population Dynamics of the Mountain Pine Beetle, with the Intermountain Forest and Range Experiment Station, Forest Service, Ogden, Utah.



## RELATED LITERATURE

- Amman, G.D. 1977. The role of the mountain pine beetle in lodgepole pine ecosystems. Impact on succession. In *Arthropods in forest ecosystems*. Proc. in the Life Sciences. Springer-Verlag, New York, Inc., New York. William J. Mattson, ed. pp. 3-24.
- Amman, G.D., M.D. McGregor, D.B. Cahill, and W.H. Klein. 1977. Guidelines for reducing losses of lodgepole pine to the mountain pine beetle in unmanaged stands in the Rocky Mountains. USDA Forest Service General Technical Report INT-36.
- Mathre, D.E. 1964. Pathogenicity of *Ceratocystis ips* and *Ceratocystis minor* to *Pinus ponderosa*. *Contrib. Boyce Thomp. Inst.* 22:363-388.
- Nelson, R.M. 1934. Effect of Blue Stain Fungi on southern pines attacked by bark beetles. *Phytopath. Z.* 7:327-353.
- Pomerleau, R. 1970. Pathological anatomy of the Dutch Elm Disease. Distribution and development of *C. ulmi* in elm tissues. *Can. J. Bot.* 48:2043-2057.
- Quellele, G.B. 1962. Studies on the infection process of *Ceratocystis ulmi* in American elm trees. *Can. J. Bot.* 40:1567-1575.
- Reid, R.W., H.S. Whitney, and J.A. Watson. 1967. Reactions of lodgepole pine to attack by *Dendroctonus ponderosae* Hopk. and Blue Stain Fungi. *Can. J. Bot.* 45:1115-1125.
- Robinson, R.C. 1962. Blue Stain Fungi in lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) infested by the mountain pine beetle (*Dendroctonus monticolae* Hopk.) *Can. J. Bot.* 40:609-614.
- Rumbold, C.T. 1941. A Blue Stain Fungus *Ceratostomella montium* N. sp. and some yeasts associated with two species of *Dendroctonus*. *J. Agric. Res.* 62:589-601.
- Theory and Practice of Mountain Pine Beetle Management in Lodgepole Pine Forests. A collection of papers presented at a symposium held at Washington State University, Pullman, Washington. Eds., Alan A. Berryman, Gene D. Amman, and Ronald W. Stark. 1978.
- Whitney, H.S. 1971. Association of *Dendroctonus ponderosae* (Coleoptera: Scolytidae) with Blue Stain Fungi and yeasts during brood development in lodgepole pine. *Can. Ent.* 103:1495-1503.

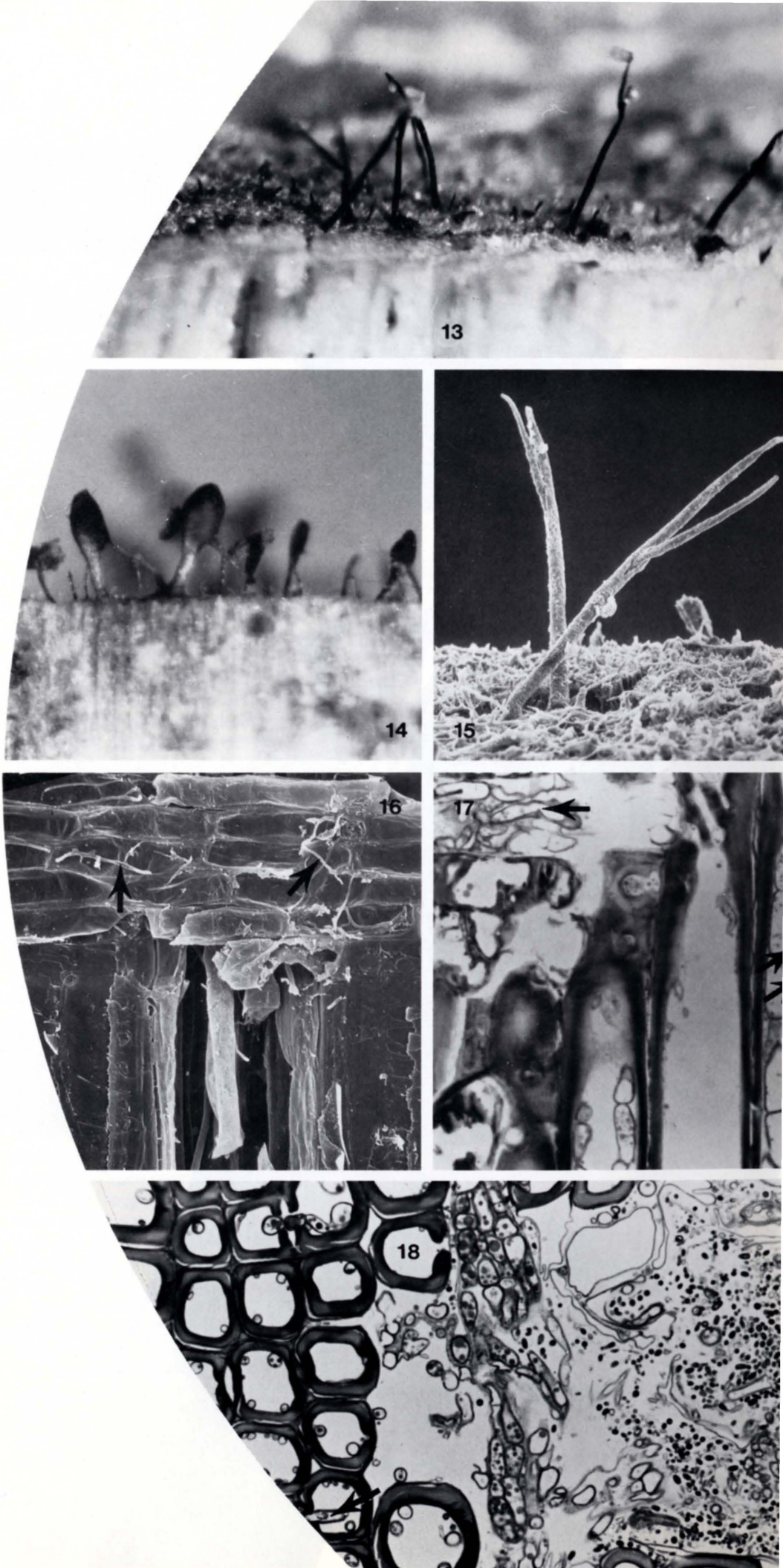
**Figures 13 and 14.** Fungal "fruiting" bodies as viewed with a compound stereo light microscope. Since several species of fungi inhabit wood, different "fruiting bodies" are present. Figure 13 shows one type, while Figure 14 shows another.

**Figure 15.** Scanning electron micrograph of part of a "fruiting body" similar to those shown in Figure 13. Fruiting bodies contain many sac-like structures that contain reproductive spores. Thousands of spores are contained within a single "fruiting body."

**Figure 16.** The hyphae (arrows), or "vegetative" part of the fungi, are shown in this scanning electron micrograph. They appear throughout the radial and axial water conducting system of the wood.

**Figures 17 and 18.** Light microscope views of wood (xylem). Fungal hyphae appear in wood rays (Figure 17, single arrow) where lateral transport of water occurs, also in axial tracheids (double arrows) where vertical transport occurs. Closer inspection (Figure 18, arrow) reveals hyphae plugging bordered pits between water conducting cells.

Figures 3 and 8 courtesy of W.E. Cole and G. Amman. All other figures by R. Ballard and M. Walsh.





# SAGEBRUS



THE SAGEBRUSH REBELLION IS SERIOUS BUSINESS. A basic strategy is to call for transfer of Bureau of Land Management (BLM) lands, and sometimes Forest Service (FS) lands, to the individual states. Twelve of 13 western states enacted related legislation. Nevada and Utah have now laid claim to large blocks of the public domain (Table 1).

Why would western legislators and public officials open themselves to the charge of supporting the "biggest land grab in history?" (Starnes 1980).

The simple answer is that the drastic alteration of federal land management patterns (developed during the 1970s) represents a threat to the livelihood of many rural families and a strangulation of development alternatives. Congress and federal bureaucrats are saying, "we are not happy with past management policies; things are going to be different in the future." The most visible and dramatic of possible responses is to call for "take-over" of federal land. At issue are 175 to 600 million acres.

In this article, we concentrate on some of the historic interrelationships in land management policies and activities of grazers to show why the "take-over" response is almost inevitable, and as a case study in federal agency unilateral alteration in federal-state working relationships of long standing. Our aim is to create a basis from which readers may be better able to make their own evaluations of all the warnings and reassurances that have peppered media reports of the rebellion's progress.



# H★REBELLION★

## AN ECONOMIC ANALYSIS

ALLEN D. LEBARON, E. BRUCE GODFREY, and DARWIN B. NIELSEN,

### IGNITING THE REBELLION

In 1976, the Federal Land Policy and Management Act (FLPMA) shifted the Bureau of Land Management (BLM) out of its historically custodian and land disposal role into a land management agency.<sup>1</sup> The Act states congressional intent to retain BLM-administered land in federal ownership. It formally repeals most or all of the Desert Entry, Homestead, or similar cheap land acts, while calling for multiple use and sustained yield management, unless otherwise specified by law. At the same time, the FLPMA calls for protection of "scientific, scenic, historical, ecological, environmental, air and atmospheric, water resources, and archeological values" and directs BLM personnel, when appropriate, to preserve and protect certain public lands in their natural condition (PL 94-579).

To some westerners, the potentials for user conflicts in mixing multiple use/sustained yield goals with "protection" were all too apparent. And when large scale FLPMA surveys to identify wilderness potentials were first announced, they immediately charged that the program was designed to "lock up" land and eliminate multiple use through legal re-classification to fit what would prove to be "non-use" categories.

Basically, it was a shared negative response to FLPMA that united western user groups and local politicians in what

has come to be called a sagebrush rebellion. In addition, the rebellion provides a platform from which to vent long felt frustration with such things as the restrictive provisions of the EPA clean air and water standards, wilderness designations, OSHA regulations, Threatened and Endangered Species Act, National Environmental Policy Act, Antiquities Act, elimination of compound 1080 for coyote control, etc.

The rebellion's backers assume that state officials will be more responsive than the federal bureaucracy to local wishes concerning utilization and future directions of development policy.

### WHAT'S AT STAKE IN THE REBELLION?

Stockmen are given the most credit for the agitation. This is understandable not only in terms of frustration, but because implementation and enforcement of the legislation cited threatens the continued existence of agricultural enterprises that are dependent upon open grazing for part or all of their receipts. Other groups may have substantial financial interest in the outcome of the rebellion but their way of life and overall livelihood are not at stake.

Elected officials at local and state levels are primarily interested in the rebellion's fiscal implications. Many of the newly treasured energy supplies of the United States are found on public lands. Lease payments, bonuses, and fees from these sources are rising and, due to various revenue sharing

arrangements, state and local governments are benefitting from the increases. They will continue to receive such benefits even if federal lands are not transferred. Government units in western states also receive other payments or subsidies due to public domain. Therefore, while the thought of obtaining all rather than part of increasing mineral revenues is tempting, the potential gain must be balanced against any revenue reductions that would accompany loss of public domain status. The first question is whether the *net* fiscal effect of a successful rebellion would be positive or negative. If the calculation is negative, the further question is, how negative? Would the additional tax load on citizens of a state be "manageable?"

Individuals or companies already in the timber cutting or extractive resource business (see Table 1), or who hope to benefit from energy developments, presumably would welcome state control if they thought lease or development procedures would be eased. Meanwhile, they make do with federal government requirements. What is important to them is not who does the leasing; they are secure in knowing that the resources of most interest to them are going to be developed one way or another. Therefore, for this group the fate of the sagebrush rebellion is not *critical* to future viability.

Arrayed against supporters of the rebellion are other user groups who see state ownership of the public domain as threatening or eroding their current

<sup>1</sup>The 1891 founding act for the Forest Service is termed the organic (goal defining) act for that agency. In contrast, when established in 1934 as the U.S. Grazing Service, the now BLM was given no clearly defined management goals. The 1976 Act is therefore termed the "BLM Organic Act."



**Table 1. STATES' LAND RIGHTS—"SAGEBRUSH REBELLION"—LEGISLATION<sup>2</sup>  
IN THE WESTERN STATES, 1979-1980  
(Current through April 17, 1980)**

STATE	Bill or Resolution	Summary of Bill or Resolution	Vote by Legislature	Effective Date
ALASKA	HCR 34	Supports Nevada on the Sagebrush Rebellion issue. Presently in Senate Resources Committee.	—	—
	SCR 42	Provides support to Nevada's legal challenge on the control of public lands. Presently in Senate Finance Committee.	—	—
ARIZONA	SU 1012	Similar to the 1979 Nevada law. Passed both Houses of the Legislature in late March 1980, vetoed by Governor Babbitt on April 8, with a subsequent veto override by the Senate on April 14, and the House on April 15, 1980.	Original Passage: Senate 20-10 House 47-11 Veto Override: Senate 21-8 House 46-8	July 14, 1980
CALIFORNIA	AB 2302	Assemblyman Hayes will not seek an override to the Governor's veto of AB 1407 from 1979. AB 2302 incorporates the concepts of AB 1407 into a more comprehensive study of the financial, legal, and land management aspects of public land ownership by the State. The Attorney General's Office, the Office of Planning and Research, and the State Lands Commission will all participate in this study. Passed out by Assembly Resources Committee and now in Ways and Means Committee.	—	—
COLORADO	HJR 1006	Provides funding for a multistate study of the effect and impact of transferring public lands from federal to state control.	House 50-10 Senate 35-0	Adopted April 8, 1980
HAWAII	SR 266	Endorses and supports the efforts of western states to gain equality with other states in land management, control, and ownership.		Adopted April 15, 1980
IDAHO	SCR 129	Directs Attorney General to explore the feasibility of supporting Nevada's public lands legal challenge, and to study whether Idaho should also seek control of the public lands.	Senate 19-16 House 55-15	Adopted March 14, 1980
MONTANA		(Legislature not in session in 1980)		
NEVADA	AB 413	In 1979 Nevada enacted a law, dubbed the "Sagebrush Rebellion," which asserts state control and ownership over the unappropriated public domain lands now under the management of the Federal Bureau of Land Management.	Assembly 38-1 Senate 17-3	July 1, 1979
NEW MEXICO	HB 79	Similar to the 1979 Nevada law.	House 48-18 Senate 25-13	May 14, 1980
OREGON		(Legislature not in session in 1980, but legislation is being drafted for 1981 session.)		
UTAH	SB 5	Similar to the 1979 Nevada law.	House 57-11 Senate 20-7	July 1, 1980
WASHINGTON	SB 3593	Similar to the 1979 Nevada law.	Senate 42-1 House 90-7 (March 10, 1980)	January 1, 1981 if SJR 132 approved by voters.
	SJR 132	Constitutional amendment to remove disclaimer clause relating to unappropriated public lands in Washington.	Senate 38-6 House 89-8 (March 10, 1980)	To be voted on by public in general election of November, 1980.
WYOMING	HB 6	Similar to the 1979 Nevada law, and also lays claim to U.S. Forest Service lands.	House 48-13 Senate 21-8	March 10, 1980

Source: Western Coalition Clearinghouse

<sup>2</sup>Utah Senator Orrin Hatch and eight co-sponsors have proposed legislation at the national level (S.1680) calling for transfer of BLM and FS lands to the various states.



positions. Some members of such groups live in the West, so ranks of the rebellion's supporters are not solid. A particular concern is that state officials could not be relied upon to perceive the public welfare in a manner that would lead to a sensible management program, especially where retention/disposal options and dollars are concerned. Finally, the U.S. citizenry at large has little inclination to give away something that is "theirs," especially if they conceive it to be valuable by any measure.

As the map accompanying this article makes obvious, what is being contended is utilization of 600 to 700 million acres—mostly in the western states. In other words, the rebellion creates an East-West confrontation. Yet, if the public domain did not exist or if it were more evenly distributed/divided throughout every state, there would be no rebellion.

### ORIGINS OF THE PUBLIC DOMAIN

Following the annexation of Texas and the close of the war with Mexico, the western population of the U.S. occupied an arc that followed the Pacific Coast through southern New Mexico and Texas to Louisiana and Arkansas. Between 1845 and 1860, mining activity caused the creation of new towns and small cities from California eastward to the front range of the Rockies. Except along river courses, however, all the land between Missouri and the Rockies, and northward from Texas to Canada was home to Indians or a few trappers. By means of land grants to states and railroads, and programs for free or cheap land sales, the federal government tried to encourage colonization of this vast area plus any portions of the far West that had not already been taken up by individuals.

Livestock owners, particularly cattlemen, soon discovered the high plains pastures, but national land policy was directed to creation of frontier opportunity for a large number of small-holders who could be expected to create permanent settlements based on the efforts of sturdy yeoman farmers.

In the end the homesteaders obtained much of the land, especially on the high plains, but the colonization process did not run smoothly anywhere. In diagram 1, we indicate some of the ups, downs, and impediments. On the high plains, would-be farmers were blown out, frozen out, and dried out before a whole new farming system was

devised that would somewhat cope with climate realities. Climate and topography were even tougher in the more arid territories west of the high plains. But these factors are only a partial explanation of why the drive for cheap land seemed so cramped in the arid zone.

The further problem west of the Rockies was that the region had already been colonized by pioneers and ex-miners and these earlier immigrants controlled the water rights and had taken up the better lands. After the Civil War, would-be colonizers, who pushed beyond the plains found only land that could not be farmed due to its topography or lack of water or both. For them there was simply no way to bring a homestead or desert entry to patent. Much of this land is now under BLM control.

Diagram 1 also ties in creation of the forest reserves. By 1891, there was a growing conservation movement, based mainly on concern for a timber resource that earlier settlers had endangered in their search for building materials, mine props, etc. This concern caused some timber lands to be withdrawn from further entry in that year. Simultaneously there was constant western pressure for irrigation because, with water, even marginal lands could continue to be taken up into farms. The 1902 reclamation act tried to accommodate both conservation and reclamation pressures. The act was not only designed to promote settlement; it also provided for reservation of a lot more forest land. This explains why westerners of the time had such mixed feelings about the new reclamation service: In order to obtain the irrigation subsidy (and possibly one last injection of settlers), they had to accept a major acceleration in the close of the public domain. And, although westerners complained bitterly and asked for the remaining unreserved lands to be ceded to the states, or for other special treatment, mineral, timber, and other lands continued to be withdrawn from further entry. By 1915, 144 million acres of the current 170 million acres of national forest had come into being. Finally, in 1934, with passage of the Taylor Grazing Act, all remaining public land effectively passed beyond the reach of the individual homesteader (except in parts of Alaska).

In today's West, the public domain is vast because one way or another private entry was frustrated. Either it was impossible to meet patent

requirements or the lands were reserved from further alienation. Had individuals taken up land in the West in anything like the proportions they did east of the continental divide, or in the Northwest, the BLM and FS either would not exist today or would have far different forms.

### ECONOMIC IMPACT OF CLOSING THE PUBLIC DOMAIN

Westerners in general were opposed to closing the public domain because the whole idea ran against their commitment to individual, competitive, atomistic development. Cattlemen on the high plains and in parts of the Rockies were sympathetic with this point of view, but had to support federal land withdrawals as a way to slow or stop further homesteader encroachment on the open ranges. They also realized that they could monopolize any grazing benefits of the newly created forest reserves because the sheep they hated were to be denied access (Pefer, Chapter 4).

Loyalties of cattlemen from west of the divide were more tangled. They knew they would get at least some grazing whether certain lands went into reserves or not. Since there was little homestead pressure, some were no doubt in a position to argue against the policy of creating forest reserves. But many others would have reacted in the same way as cattlemen on the other side of the divide; not because of homesteading pressure, but because they held base property that irrigation features of the Reclamation Act might make considerably more valuable in the future. So, in effect, they supported the withdrawals.

In 1891, when lands started to be excluded from farmer entry, no one knew to what degree the public domain would be closed. All that was really known was that the cheap land acts would not be successful in the arid zone of the American West. The great national pasture east of the continental divide might or might not be suitable for dryland farm techniques, but further west, marginal grazing was all that was possible in the absence of irrigation.

This reality led to development of a semi-viable agricultural system primarily centered around water rights held in association with base property plus a certain amount of respect for the summer-mountain and winter-desert "territories" that the animals of individual families traditionally grazed. The main destabilizing aspect was the presence of nomadic sheep flocks and







This map shows Federal ownership and trusteeship by administering agency to the extent the scale permits. Areas smaller than a township (36 square miles) generally are omitted. Areas shown represent holdings as of early 1968 with some updating for significant changes during 1968. Co-administration of areas is shown where administration is divided about equally between agencies.

The map scale does not permit exclusion of areas of nongovernment lands smaller than a township contained within proclamation boundaries. The Fish and Wildlife Service has extensive areas with proclaimed boundaries which contain relatively little Federal ownership. Such areas have been omitted if less than 25,000 federally owned acres are inside the proclamation boundaries.

Several proposed recreation areas are shown which, while accommodating visitors, were not legally established national recreation areas by January 1, 1968. National recreation areas smaller than 25,000 acres are either included as other types of adjacent Federal land or, if isolated, omitted.

The Indian lands are enclosed by boundaries established by treaties or proclamations. In most cases these boundaries enclose more acreage than is held in trust, for it is impractical to separate trust lands from other interspersed lands.





cattle herds that invaded the territories of the sedentary ranchers from time to time.

Pressure slowly built for some system of managing range rights outside the forest reserves. This peaked in the early 1930s when it became apparent that the great depression would further reduce rural incomes, which had already suffered during the decade following the close of World War I. Although Nevada's Pat McCarran suggested that misuse of resources could be corrected if public lands were turned over to the states, the remedies finally chosen were embodied in the Taylor Grazing Act of 1934.

That act was designed in large measure to end confusion in grazing activity, and raise incomes by somewhat restricting meat supplies. It also, however, specifically called for setting aside (the few) lands suitable for continued desert entry; a feature suggestive of the spirit of all earlier cheap land acts, even though, for the majority of the land, only some rights to grazing the surface of the land rather than the land itself were involved.<sup>3</sup> If rights to the forage had been granted or sold in perpetuity, there would have been more consistency with the treatment received by Homestead Act beneficiaries. A perpetual right would have encouraged careful management on the part of the original grantees or their heirs in order to protect the long-run value of the resources. Because renewal of grazing rights was never guaranteed, the 10-year lease system had some tendency to create the exact opposite effect on management incentives.

Even so, the 10-year leases gave definition and form to individual ranching enterprise since the leases usually were renewed, and permits were eventually tied to specific herds or flocks associated with certain base property. The lease rights for either national forest or Taylor Act lands obviously had value over and above the annual fee charged. One way or another, permits were traded or used as collateral, and this utility necessarily got capitalized into the value of the base property.

A little over a decade ago, both the BLM and FS finally accepted the fact that permits did have value and that management policy shifts involving sizes of allotments, permit numbers, etcetera,

arbitrarily enhanced or destroyed the wealth of individual ranchers via immediate alteration in the capitalized value of base property. In order to weaken what was being viewed in the market place (by banks, escrow agents, and individuals) as a property right and to unshackle future land management decisions, agency officials decided to raise the annual grazing fee to a level that would drive the capitalized values of the outstanding permits to zero. When it was pointed out that the proposal would be a terrific blow to recent purchasers of high-value permits, the agencies' reaction was to stage the fee increase over a 10-year period. This decision merely slowed the wealth erosion process for many rural families.

American land colonization policies that worked in the East, Midwest, and high plains could not build a rural, agrarian economy in the arid zones west of the continental divide. However, with the full knowledge and support of the federal government, a minority rural population in the arid states incorporated use of the public domain into an agricultural system that was technically feasible under the given circumstances. Even today, there is no hard evidence that these technical possibilities have altered. What has changed since the late 1960s, are the "givens." BLM and FS management practices have been drastically altered by law and application. In the process, a great amount of uncertainty and instability have been introduced into Intermountain ranching operations. This is the economic basis of the ranchers' commitment to the sagebrush rebellion.

### THE WESTERN PARTNERSHIP

During much of the first half of the twentieth century the underdeveloped American West was largely dependent on the East for potential settlers, for markets and supplies, for cultural values and institutions, and for political power that would help facilitate western development. This heavy dependence of the West on the East inevitably cultivated a state of mind among westerners that had many of the earmarks of a love-hate relationship (Nash, p. 6).

In tourism and leisure lifestyles, national leadership gradually came to western states. In addition, the great depression and World War II induced shifts in population and attendant markets plus growth in regional manufacturing. The results could be interpreted as an apparent unburdening

of the West of most of its earlier colonial status. In reality, the reduced dependence upon eastern finance and control was accompanied by increased dependence on the federal government.

This dependence on federal largess has not been simply a phenomenon of rural and urban depression in the 1920s and 1930 or of wartime spending. Even in the 1950s or 60s, public figures regularly remarked on the degree to which western employment and prosperity depended on "government jobs." Westerners pioneered in working out a myriad of relationships (many involving subsidy) between themselves and federal, state, and local governments to hasten growth. In this endeavor, they were ahead of the rest of the nation by at least a generation.

Among the major political trends first worked out in the West was a new cooperative relationship between the federal government and private enterprise which has been widely accepted throughout the rest of the nation. Rather than being a product of individual initiative and enterprise, the West is a prime example of mixed enterprise, of a partnership between private individuals and federal, state, and local governments (Nash, p. 295).

Between 1900 and 1970, the federal government spent more than \$300 billion in developing the trans-Mississippi region. At least another \$75 billion was spent by state and local governments for public works, social services, or to attract new industries. Nash has estimated that this sum is about one half of the capital that was needed to settle the West. Western congressmen alternately wooed and harassed federal bureaucrats for a voice in dispersing this enormous cornucopia.

### POLITICS OF THE NATURAL RESOURCES PARTNERSHIP

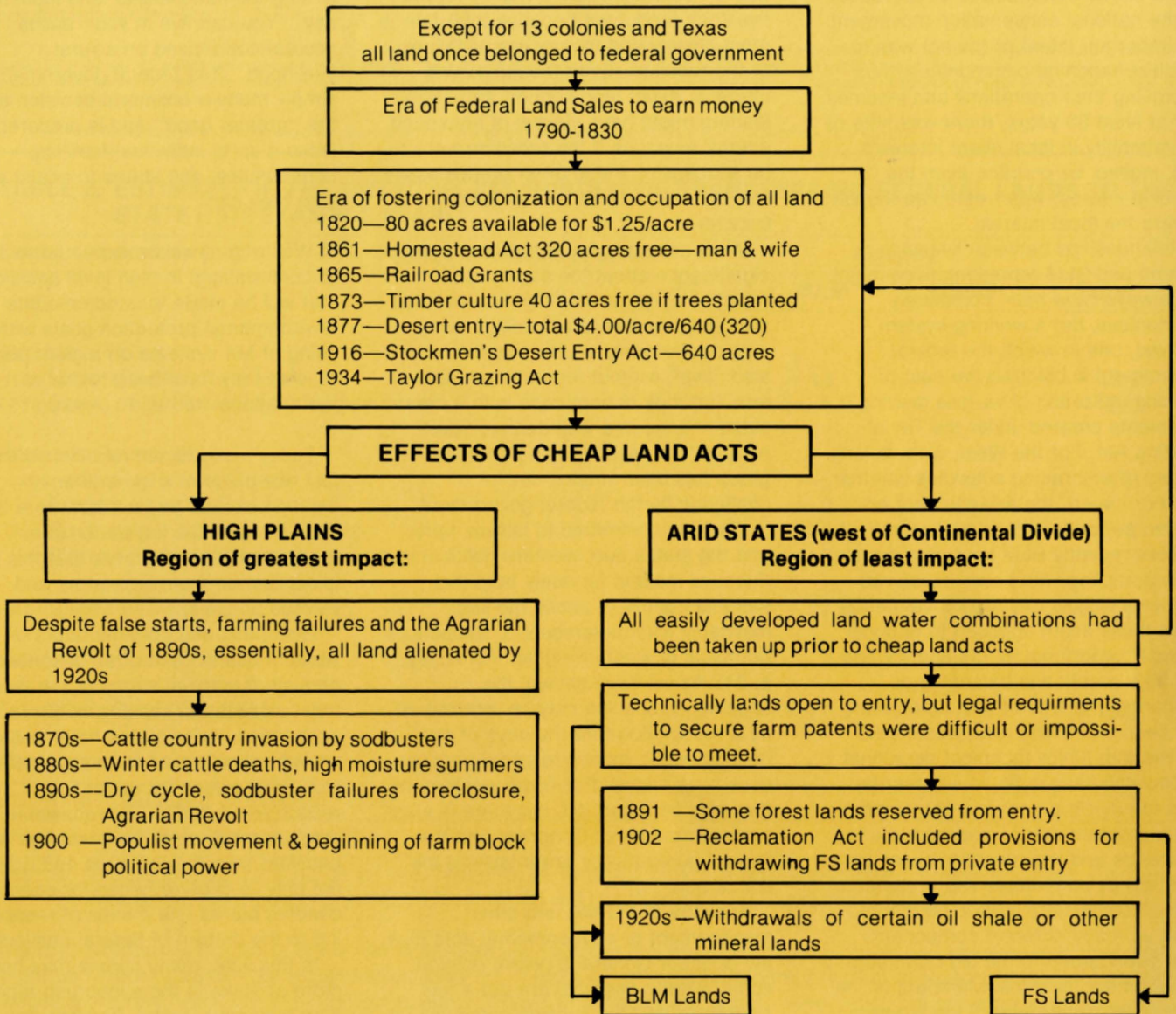
But western politicians found that they were up against a new kind of bureaucrat—one that could not be manipulated in good old patronage style. The same process that closed the public domain also created a nationalized natural resources industry. To manage this industry required a kind of expert bureaucrat—the scientist in government. It's well known, of course, that it's difficult to argue with experts, especially if they have money. Western congressmen and other public officials therefore had to establish an intimate, cooperative association with Washington technocrats interested in developing their new dominions.

<sup>3</sup>The act required that arable lands be identified and set aside for continued entry. In addition, the Carey Act allowed some entry even after World War II. And some homesteading has been possible in certain parts of Alaska.



DIAGRAM 1

# ORIGINS OF TODAY'S PUBLIC DOMAIN IN ARID WEST



An operational feature of the large, technical bureaus for the past several decades, is that powerful bureau chiefs frequently originate the very policies they are charged with executing (Gressley, p. 22). The ability to do this is based on tenacity and a willingness to depend on more than mere manipulation of bureaucratic machinery. What is required is to create a cooperative, symbiotic relationship between the key

client group and the bureaucracy.<sup>4</sup> If the result is perceived to be closely allied with a broader national client interest, so much the better.

<sup>4</sup>Key client groups are those who know what they want from the Federal Bureaus. "(Arthur Powell) Davis forged a workable reclamation policy along the lines of authority and influence that ran between Washington and the water users. All the while he was cajoling the water users, he was simultaneously ramming his ideas through the Department of the Interior. Then he selected men to carry out these policies in the field" (Gressley, p. 22).

Given the FS's basis in the conservation movement, we might expect a considerable divergence in local/national client interests. Yet, if we discount the early years of its history, management and manipulation of the bureaucratic/client machinery has been eased because western lifestyles, growth of tourism, etcetera, revealed a multiple use potential that included many local clients whose desires



meshed with management policies that would satisfy a continuous conservation mandate.

Until recently, the situation facing BLM personnel has been quite different. In the first place, the Taylor Grazing Act could not be construed to be a product of the national conservation movement. An important intent of the act was to stabilize ranching communities, thus improving their operations and incomes. For at least 30 years, there was little or no variability in local client interests and, indeed, by practice even the national interest was treated as though it were the local interest.

Relationships between livestock owners and BLM representatives might not always have been completely harmonious, but a working system evolved, one in which the federal government subsidized the cost of policing utilization of various grazing allotments created under the Taylor Grazing Act. For the West, with its long history of embracing subsidies whether overt or covert, the arrangement appeared perfectly natural and proper.

More recently BLM personnel have been grappling with newly perceived problems in how to satisfy local needs when these seem opposed to national "good." Unfortunately the agency has had little practice in balancing or mastering this type of mix. One result has been that many rural westerners believe that junior technical personnel (especially) have used environmental laws to jury-rig a conservation emphasis into a program that is inappropriate for thousands and thousands of acres that have few or no multiple use pretensions.

Such complaints tend to be ignored since so many different components have been added to the old bureaucratic management machine. Members of the technocratic hierarchy of the bureaus most affected are occupied with learning new manipulative and control techniques. In the process, they are giving much more weight to a national interest couched in conservation terms; essentially they are repudiating any need for further support from a local-interest clientele they believe to be anti-conservation by nature.

Since cattlemen have difficulty regarding their use of a federally managed resource as being anti-conservation, the withdrawal of the "feds" from a working partnership of long-standing is particularly galling. To most of them, it is as though a social contract has been breached, and the

consequences are regarded with that particular bitterness that comes from betrayal.

### A NEW COLONIALISM?

The interpretive history presented above has concentrated mainly on the livestock producers because their fate is most closely tied to success or failure of the rebellion. Even though mining interests might lend support and state leaders might have visions of enhanced energy revenues if the rebellion were to be successful, these other groups easily can live with lack of federal land transfer.

What seems to be of most significance about the sagebrush rebellion is its inevitability. It's true that the relatively few rural families living outside the western urban oases could also "live" without federal land transfers, but they cannot cope with a one-sided change in a well defined "partnership." In essence this particular group has been *singled out* for challenge by the federal government.

"Deeply committed to laissez faire and the status quo, western political and financial leaders fervently held that national control of public monies inevitably was tantamount to treasonous betrayals of western rights" (Gressley, p. 24). As we have shown, the sagebrush rebellion may be interpreted as a recognition that the days of connecting public money to certain private uses have ended. For some westerners that may be a bad jolt, but there is also a deeper meaning: Congress and the federal bureaucracy are attacking the status quo.

Passage of FLPMA and other management or environmental acts plus the Solicitor General's recent opinion about water ownership are but a few evidences that the subsidy game will be handled differently in the future. Three less obvious examples that the rules are being changed are:

**a)** Persons and groups who are concerned with preservation of nature in general are the client force now tied most strongly into the bureaucratic machine. Their aims and desires have significantly increased the cost of a nationalized resource operation. A major portion of federal land management subsidies are now going not just to a general class of users called "recreationists;" they are going to particular, definable sub-classes which either pay nothing for use of the federal

domain or are moving into a position to deny benefits that others might wish to enjoy;

**b)** In effect, the most recent trends in laws and interpretations of laws affecting the nationalized land industry say, "You can live in your 'oases,' but you cannot depend on a rural livelihood." The federal government has simply made a unilateral decision about the "greater good" and is prepared to leave it up to individual families, communities, and states to adjust as best they can;

**c)** Westerners will be expected to adjust to contradictions in high level decisions that will be made to accommodate environmental protection goals with the siting of MX systems on a giant portion of what they have been told is part of the "national heritage" (Andrus 1979).

Today's sagebrush rebellion is thus just one piece of a general emancipation issue. The fact that there is such thing as the legislation summarized in Table 1 proves that this point is not lost on state legislators and elected officials.

Historians and commentators on the western scene have often described the persistent colonial status of the West's most arid states. Lacking viable economies, these states have existed on federal subsidies for many years. Now, with prices for extractive resources (including the renewable ones) soaring, a natural response is to consider transfers of lands and rights, not only to capture hoped-for economic benefits but as one means of responding to the pattern of federal challenge.

In this light, many people may have more at stake in the sagebrush rebellion than they now realize. Perhaps the rebellion marks a time for the Intermountain West to stand on its own feet, cut the federal apron strings, and take the bad with the good. To survive on its own, every arid state will need as much natural resource base as it can claim. Otherwise, the West will continue to be told "what (is) good for it and, as always, (will) take the medicine prescribed" (Athearn, p. 289).

### BIBLIOGRAPHY

- Andrus, C.D. 1979. The Sagebrush Rebellion Fences Out the Majority. FARM: The future of agriculture in the Rocky Mountains. Institute of the American West, Sun Valley, Idaho, October, 1979.



# CAN STATES AFFORD TAKEOVER?

AS FAR AS BLM LANDS ARE CONCERNED, the general answer is a qualified yes if the states obtain all mineral and timber rights. Oregon, New Mexico, and Wyoming would be "in the black" immediately.\* Utah and Nevada would be "in the red" in relatively small amounts.\*\* Other states might be better or worse off. Alaska aside, Idaho taxpayers would face possibly the biggest relative burden.

\*This conclusion is based on timber sales data for Oregon O & C lands (Public Land Statistics, 1977, Table 114); Range Improvement Task Force, estimated benefits and costs of state ownership of Bureau of Land Management Lands in New Mexico, Cooperative Extension Services, Report #1, January 1980; BLM and FS Lands in Wyoming; background information and considerations involved in possible transfer of state ownership and control, Memo to Governor of Wyoming; prepared in Depts. of Agriculture Economics & Range Management, College of Agriculture, Wyoming Univ., January 1980.

\*\*Memo to Research Director, Nevada Legislative Counsel Bureau from administrator, Division of State Lands, p. 5 attachment, April 12, 1979.

**TABLE 2. ESTIMATE OF THE NET UTAH TAX BURDEN OF TRANSFERRING FEDERAL LANDS TO THE STATE (1978 EXAMPLE YEAR)**

Cost ( - ) or return ( + )	Figures in millions of dollars			Agency
	FS	BLM	USGS	Total
Additional Costs				
Expenditures, state level	- 26.9	- 15.1	- 1.4	- 43.4
Share of National/Regional overhead	- 7.0	- 5.0	?	- 12.0
Reduced Revenues				
Federal Highway Funds	- 3.0	- 5.8	0	- 8.8
Forest Highway Funds	- 1.1	- 0	0	- 1.1
Payments in Lieu-taxes	- 2.0	- 3.5	0	- 5.5
Shared Fees and Revenues	- 0.9	- 12.0	0	- 12.9
Increased Returns	+ 3.6	+ 27.6	+ 0	+ 31.2
Possible Reduction in Overheads	+ 3.5	+ 2.5	0	+ 6.0
Estimating Operating Cost	- 33.8	- 11.3	- 1.4	- 46.5
Allowance for Amortization ( - ) of Agency Capital Items	- 3.85	- 0.75	0	- 4.6
Est. Total Annualized "Takeover" Cost	- 37.65	- 12.05	- 1.4	- 51.1
Share of 1980 Utah State Budget (%)	2.4	0.8		3.3

Source: An Economic Evaluation of the Transfer of Federal Lands in Utah to State Ownership, Four Corners Regional Commission Contract 501-400-015-4, Utah Agricultural Experiment Station, Logan, May 1980.

The Utah estimate is indicative of the net relative annual increase in state expenditures. The actual amounts in a given year might be higher or lower. The expenditures allow for "takeover" of ongoing federal program at existing levels of intensity (wages, personnel, vehicles, sub-program budgets, rentals of space of equipment—everything but some pension accounts). These net costs could be reduced by: 1) reduction in level of management effort. 2) up to 50 percent reduction in costs "additional costs" because states would not have to spend so much money on environmental studies; 3) greater "returns" due to higher fee charges and/or expanded programs of land utilization.

Gressley, G.M. 1977. The 20th Century American West. Columbia: University of Missouri Press.

Nash, G. 1973. The American West in the 20th Century: A Short History of an Urban Oasis. Albuquerque: University of New Mexico Press.

Petfer, E.L. 1951. The Closing of the Public Domain. Food Research Institute No. 10. Stanford: Stanford University Press.

Starnes, R. 1980. The Sagebrush Rebellion. Outdoor Life, March 1980.

## ABOUT THE AUTHORS

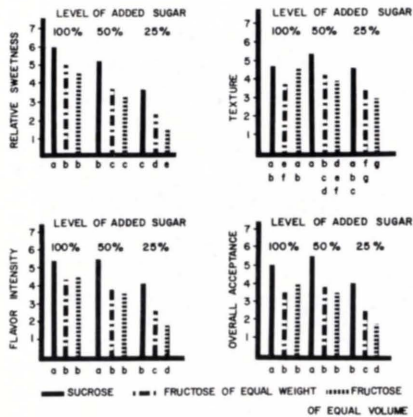
Dr. Allen D. LeBaron is a Resource Economist in the College of Agriculture at USU. His main research interest has been in the economic impacts of public policy and investment decisions in land and water management. He has had extensive advisory and research experience in Third World countries. A main interest is the economic history of the American West.

E. Bruce Godfrey is an Associate Professor in the Department of Economics at Utah State University.

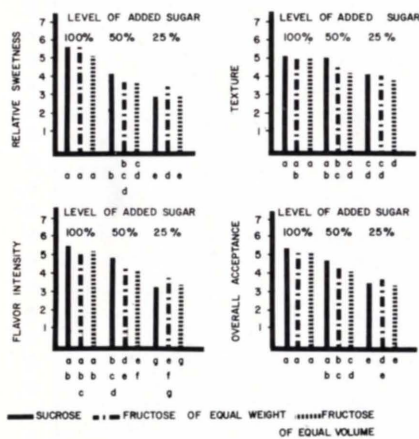
Darwin B. Nielsen is Professor of Agricultural Economics. His research interests are in range and ranch economics of beef cattle and sheep production, emphasizing management decision making. In addition, Dr. Nielsen is interested in the economic impacts of federal government regulations and policies on the range livestock industry.



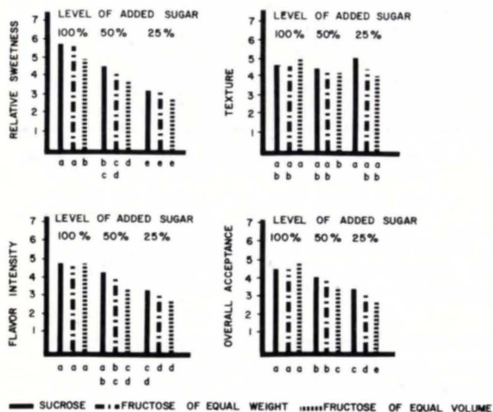
# SUCROSE



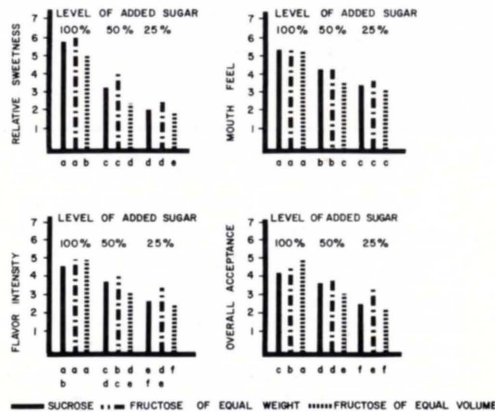
**Figure 1.** Sugar Cookies: Comparison of average sweetness ratings for different levels of sucrose and fructose.



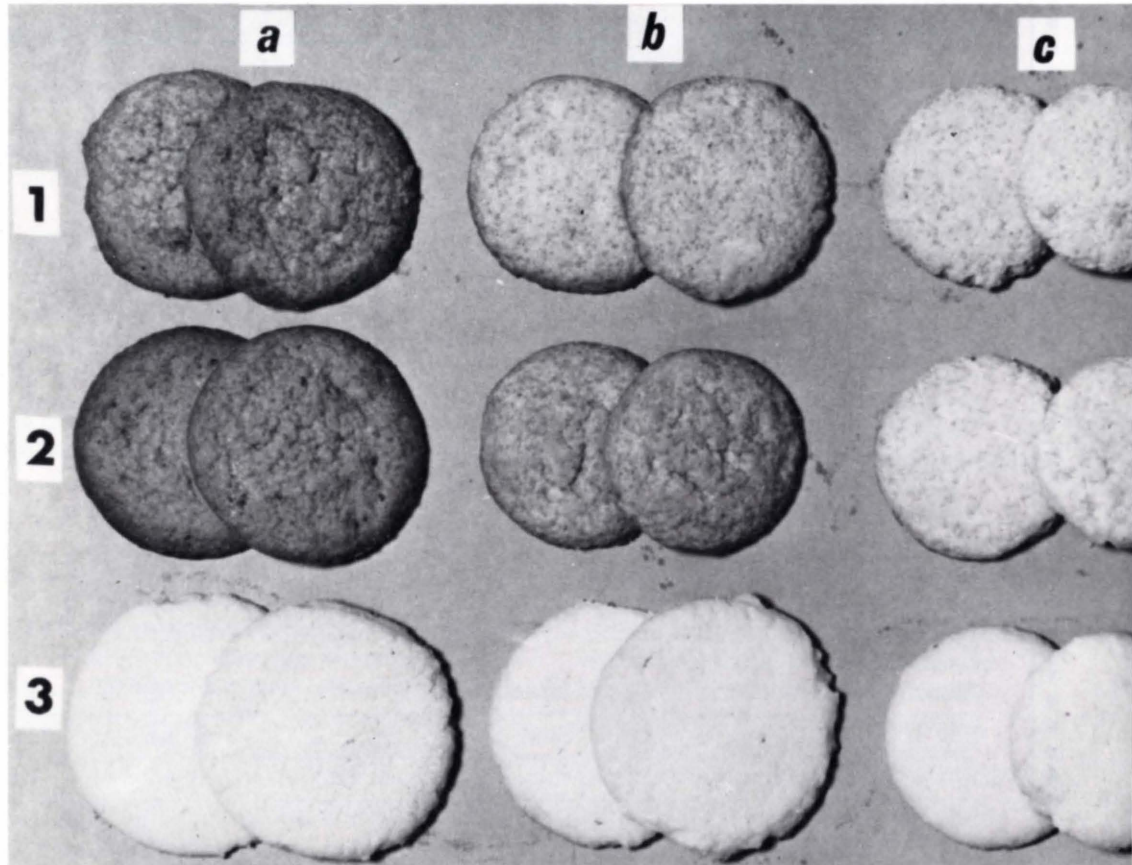
**Figure 3.** White Cake: Comparison of average sweetness ratings for different levels of sucrose and fructose.



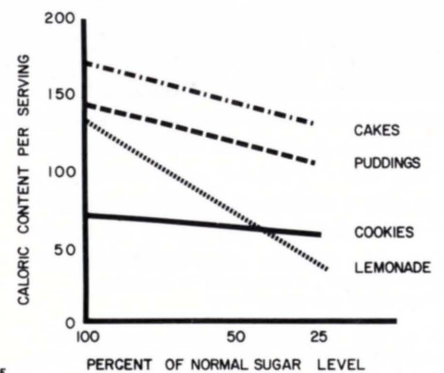
**Figure 4.** Vanilla Pudding: Comparison of average sweetness ratings for different levels of sucrose and fructose.



**Figure 5.** Lemonade: Comparison of average sweetness ratings for different levels of sucrose and fructose.



**Figure 2.** Browning and spread variation in sugar cookies made with sucrose or fructose at three levels. Key: a = 100 percent, b = 50 percent, c = 25 percent of normal sugar level; 1 = fructose by volume, 2 = fructose by weight, 3 = sucrose.



**Figure 6.** The effect of decreasing sugar on caloric content of the foodstuff.



# VS. FRUCTOSE

## IS SUGAR A KEY TO CALORIES?

THE ANSWER TO THAT QUESTION has to be—only sometimes. In many cases, the caloric content of a sugar-bearing food is more dependent on its other ingredients. Our recent efforts to compare fructose and sucrose made that abundantly clear.

As counting calories grew in popularity as a U.S. sport—so did public interest in low-calorie ways to satisfy a craving for sweetness. Scientists had long agreed that different forms of sugar (e.g. sucrose, table sugar; lactose, milk sugar; fructose, fruit sugar; glucose, blood sugar) varied in sweetness as well as chemical configuration. The major potential for controversy centered around whether fructose, which consistently ranks as exceptionally sweet when tested in water solutions, could both free diabetics from artificial sweeteners and allow dieters to use less sugar, thereby decreasing calories.

### The Whys and Hows

Our research goals were to identify and compare sweetness and other general sensory perceptions of sucrose and fructose at different levels in a variety of products. The items chosen to represent food systems that include sugar were sugar cookies, white cake, vanilla pudding, and lemonade.

The four products were created using standard proportions and preparation methods. All products were prepared using 100 percent, 50 percent, and 25 percent of the normal amount of sugar. The major comparison was between sucrose and fructose, but two versions of each of the fructose samples were necessary because fructose available to consumers has a substantially lower specific gravity than sucrose. We used fructose by weight for scientific control and fructose by volume because consumers commonly measure by volume (cup, tablespoon, etc.), and this slightly lower amount might make a difference. Taste evaluations of each product were made by panels of ap-

proximately 25 judges. (Our procedures and other details of this research have been reported in the volume 24, January 1979 issue of the *Journal of the American Dietetic Association*.)

### The Results

Contrary to current advertisements and generally accepted beliefs, fructose did not sweeten all products more efficiently than sucrose. Since fructose is more chemically reactive than sucrose, some of it enters into reactions such as browning and thus is no longer available for sweetening in heated products.

Sucrose cookies were rated significantly higher than those made with fructose for sweetness, flavor, texture, and overall acceptance (Figure 1). The two fructose measures (volume and weight) were perceived as differing only at the 25 percent sugar level. But at 25 percent, only the sucrose cookies were considered to have overall acceptability.

The two sugars produced unmistakable differences in the appearance of the cookies (Figure 2). Fructose cookies, besides browning more, were much more moist and chewy (even after several weeks of storage in a plastic bag at room temperature), while the sucrose cookies were crisp. The cookies made with fructose were also described as having a honey-like flavor, and some judges noted a slick-mouth feeling after eating these cookies.

In the cake samples, the amount of sugar used made more of a difference to the taste panel members than did the type of sugar (Figure 3). Only at the 25 percent level of sugar did the panelists identify either sugar as more (or less) taste effective. With 25 percent sugar, fructose seemed a more effective sweetener, but even so, all those cakes were rated as unacceptable. Again, fructose cakes underwent more browning than did sucrose cakes.

The pudding samples produced no surprises. As with the cookies and cakes, sucrose puddings were ranked as sweeter, although not significantly (Figure 4). Amounts of either sugar were more important than type to overall acceptability, with 25 percent puddings being uniformly unacceptable.

In lemonade, however, the fructose-by-weight samples were definitely considered to be sweetest. In the fructose-by-volume (less weight) samples, however, sucrose was perceived as giving more sweetness. At or below the 50 percent level, none of the sugar variables produced acceptable lemonade (Figure 5).

Our calorie determinations indicated that decreasing the sugar content had relatively little effect on the caloric content of sugar cookies (Figure 6) when the cookie size remained constant. The increased volumes of fat and flour per cookie (as sugar was decreased) kept the calorie count almost level. Only in the lemonade was there a major correlation between sugar content and caloric count.

Based on our results, calorie-counting individuals are not likely to benefit if they substitute fructose for sucrose. They'll have to stay with the only guaranteed way of decreasing caloric intakes—eat less and exercise more. For diabetics, the reported advantages of fructose over sucrose remain equivocal, and will require research of a different type than we have completed.

### ABOUT THE AUTHORS

Charlotte Brennand taught at the University of California before coming to USU twelve years ago. She is an Assistant Professor of Nutrition and Food Sciences with a research concentration in flavor chemistry and sensory evaluation.

After receiving her Master of Science degree from USU in 1977, Sherrie Hardy was appointed Therapeutic Dietician for Primary Children's Hospital in Salt Lake City.



# Trends in Utah's Fruit Production

ROICE H. ANDERSON



UTAH ACRES DEVOTED TO FRUIT TREES have declined from over 13,000 in the 1920s to just under 10,000 acres in 1979. This decrease typifies the national shift from diversified to specialized agriculture within particular geographic regions. Under competitive commercial conditions, the area of production of each crop gradually shifts dependent upon all environmental, physical, and economic factors. Fruit production in Utah accounts for about five percent of the value of the state's total crop production while using only one percent of the crop land.

Unlike some crops, fruit trees are adapted to relatively high, steep slopes and stony, light soils where frost is less severe. Their other requirements are very demanding, so the Utah acreage adapted to fruit production is limited.

That same acreage, however, can be attractive to developers. The per acre value of a fruit crop is high enough to cover the labor and other input requirements, but can't compete with housing.

By comparing results of a 1979 fruit growers survey in Utah with those obtained in 1972, a detailed description was derived of recent trends in Utah's fruit industry.<sup>1</sup> The survey included all fruit growers of the state who were working with 100 or more trees of any one kind of fruit and could thus be classed as commercial producers.

There were 499 commercial growers in 1979, down 41 percent from 841 in 1972. Fruit trees on commercial farms decreased 10 percent from 1972 to 1979, while the trees per grower increased by 52 percent.

**Trends are for more apples,  
sour cherries, and peaches  
from fewer acres.**

<sup>1</sup>Utah 1979 Fruit Tree Survey. Utah Crop and Livestock Reporting Service. USDA in Cooperation with Division of Plant Industry, Utah Department of Agriculture.







## Changes in size and location of growers

Although 16 of Utah's 29 counties have some fruit trees, Utah and Box Elder have 85 percent of the total and Davis, Weber, and Washington counties have an additional 10 percent of the total. Ten of 11 other counties each have less than one percent and these 11 counties combined have only five percent of the state's fruit trees.

In Utah County, where 67 percent of the fruit trees of the state are located, tree reduction was only five percent from 1972 to 1979. The number of commercial growers decreased 51 percent and trees per grower increased 94 percent (from about 1,700 to 3,300).

In Box Elder County, where 18 percent of Utah's fruit trees are located, the trees per grower in 1979 number only 1,871, compared with 3,294 in Utah County. The decline in number of operators from 1972 to 1979 was only half as great, 26 percent. The large percentage decrease in number of trees in Davis and Weber Counties (57 and 44 percent, respectively) as well as the decrease in trees per operator probably resulted from residential encroachment on fruit land in these two counties.

When Utah's fruit growers were classed into fifths according to the size of their operations, the largest fifth (100 in number) averaged more than 8,000 trees each in 1979 and had 78 percent of the state's commercial trees (Table 1). The smallest fifth averaged only 164 trees each and accounted for less than two percent of the total.

## Kinds of fruit trees and indicated changes

Apples, tart cherries, and peaches (in that order of importance) accounted for 85 percent of Utah's fruit trees in 1979. Although all trees declined 10 percent from 1972 to 1979, apples increased by eight and tart cherries by 16 percent. The other kinds of fruits decreased, varying from 18 percent for peaches to 63 percent for apricots (Table 2).

Utah's commercial fruit growers had various combinations of kinds of fruit on their farms, with 72 percent of all growers in the state having peach trees and 52 percent having 100 or more peach trees (Table 3). Peaches, apricots, and tart cherries predominated in Utah County orchards. Although a fifth of all commercial growers had plum trees, only two percent in all areas had 100 or more plum trees.

Utah County, with 67 percent of all the state's fruit trees, had proportionately more apples, 77 percent; pears, 82 percent; and tart cherries, 71 percent (Table 4). Box Elder County, with 18 percent of the total, had 47 percent of the apricots, 33 percent of the peaches, and 45 percent of the plums. All other counties combined had more apricots, sweet cherries, and plums than their composited proportion.

## Indicated trends in kinds of fruit grown beyond 1979

In the 1979 survey, each grower was asked to indicate the number of trees he or she would set out in 1979. While not a measure of net increase, since the number of trees to be removed was not specified, it does indicate some direction of change for the future.

Trees to be set out in 1979 as a percent of current inventory varied from five percent each for apples, peaches, and sweet cherries; 16 percent (each) for apricots and tart cherries; to 195 percent for plums (Table 5).

Plums to be set out in 1979 amounted to 12 percent of total trees, double the 1979 inventory number in the state. Eighty-five percent of new plantings of all kinds were scheduled for Utah County farms and 11 percent for Box Elder County farms.

## Varieties of apples

Red Delicious accounted for 69 percent of all apples grown in Utah. Next were Golden Delicious, 13 percent; Rome Beauty, 10 percent; Jonathon, 6 percent; and all others, 3 percent. Standard trees of all varieties accounted for 30 percent and dwarf and semi-dwarf accounted for 70 percent of all apple trees. The number of dwarf trees per acre was nearly double that of standard trees, 138 compared with 74 as an average for the state for all apple varieties.

Trees to be set out in 1979 in percent of the 1979 inventory indicated a rate for dwarf trees nearly double that of standard trees. Rome Beauty dwarf was the variety showing the greatest proportional set out rate at 20 percent of inventory or four times the average of all apple trees. Unnamed "other" dwarf trees were indicated for 1979 set out at double the all apple rate of five percent.

## Varieties of peaches in the state

Classified by maturity date, 53 percent of Utah's peaches were late

varieties (after September 15). One-third were mid-season (August 25 to September 15) and 14 percent were early (before August 25).

The Hale variety accounted for 29 percent; Elberta, 16 percent; early Elberta varieties, 22 percent; and Red Haven, 5 percent of all peaches in the state. About a dozen other varieties made up the remaining 18 percent of all peaches.

Peach trees to be set out in 1979 as a percent of inventory were five percent. The shift is toward early maturing varieties, with Red Haven being the most popular.

## Summary

Five hundred commercial fruit growers in Utah maintain just over one million fruit trees. One hundred of the growers account for more than 75 percent of the total. Each of these maintains 2,000 or more trees, with an average of 8,000 trees.

Utah's fruit production is and will continue to be concentrated in Utah County as housing and other non-agricultural encroachments take their toll from fruit-growing land in other counties.

Specialization prevails as apples and tart cherries persistently increase in number of trees while peaches, sweet cherries, pears, and apricots decrease.

Red Delicious, with 69 percent, and Golden Delicious, with 13 percent of all apples are the predominant varieties. The Hale peach is most prevalent, but there is a trend toward early maturing varieties like the popular Red Haven.

The commercial fruit industry, occupying about one percent of Utah's crop land and accounting for five percent of the value of all state crops, will continue to be a major source of income for about 100 producers and make a significant contribution to the incomes of another 400. Utah consumers will benefit by having access to locally produced, picked at its peak, high quality fruit of many kinds and varieties.

## ABOUT THE AUTHOR

Roice H. Anderson is Professor of Agricultural Economics and Extension Marketing Specialist, Utah State University. His present activities include a study of small and part-time farming in Utah for the Utah Agricultural Experiment Station, and his major assignment for Extension Services is the agricultural outlook.

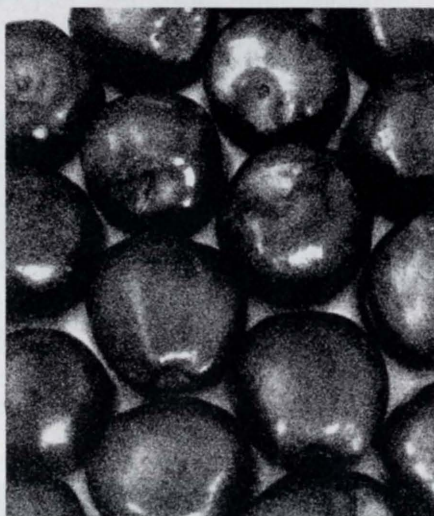


**Table 1. Utah's commercial fruit growing operations in 1979 categorized into fifths based on numbers of trees**

	Average trees per grower	Total trees	Percent of total
Smallest fifth	164	16 401	1.6
Second fifth	308	30 754	3.0
Third fifth	534	53 378	5.1
Fourth fifth	1 268	126 761	12.2
Largest fifth	8 203	812 124	78.1
All Growers	2 083	1 039 418	100.0

**Table 2. Kinds of fruit trees in Utah in 1972 and 1979 and change during the period**

Kind of fruit	Percent of state's trees		Percent change
	1972	1979	
Apples	31	37	+ 8
Apricots	3	1	- 63
Cherries, sweet	14	8	- 49
Cherries, tart	20	26	+ 16
Peaches	24	22	- 18
Pears	7	4	- 44
Plums	NA	1	NA



**Table 3. Percent of Utah's commercial fruit growers having each kind of fruit and percent having 100 trees or more of each kind in 1979**

	Percent of growers with each kind			State
	Box Elder County	Utah County	All other counties	
Apples	52	74	72	69
Apricots	44	25	44	37
Cherries, sweet	65	66	54	61
Cherries, tart	69	48	27	44
Peaches	86	63	75	72
Pears	21	45	43	39
Plums	24	15	28	21
<b>Percent of growers having 100 trees or more</b>				
Apples	29	63	45	50
Apricots	17	3	7	7
Cherries, sweet	32	38	26	32
Cherries, tart	60	38	12	33
Peaches	70	47	47	52
Pears	5	27	9	16
Plums	2	2	2	2

**Table 4. Percent of each kind of fruit tree in various areas of Utah in 1979**

	Percent of Utah's trees by kind			
	Box Elder County	Utah County	All other counties	State
Apple	8	77	15	100
Apricot	47	17	36	100
Cherries, sweet	18	60	22	100
Cherries, tart	21	71	8	100
Peaches	33	51	16	100
Pears	3	82	15	100
Plums	45	34	21	100
<b>All kinds</b>	<b>18</b>	<b>68</b>	<b>14</b>	<b>100</b>

**Table 5. Fruit trees to be set out in 1979; Utah, and selected counties**

Kind of fruit	Trees to be set out in 1979			
	Percent of all fruit	Percent of inventory	Percent in: Box Elder County	Utah County
Apples	21	5	11	83
Apricots	2	16	86	1
Sweet Cherries	4	5	0	92
Tart Cherries	47	16	9	91
Peaches	13	5	17	71
Pears	*	1	0	70
Plums	12	195	0	99
All fruit	100	9	11	85

\*less than 0.5 percent.





Foods such as these cherries, spinach, and celery have been freeze dried, compressed, and packaged and can be successfully stored for a year with little or no loss of taste and nutritional quality.

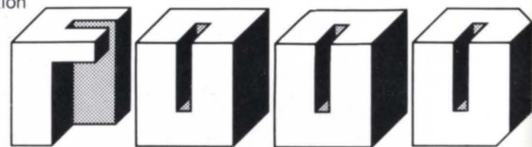
The bags on the shelf below have been produced for the U.S. Army in dark green. They can be manufactured in all colors and cost approximately 1/2 cent apiece.

Our familiar canned products can cost as much as 23 cents for each container...not to mention the environmental costs of throwing away our valuable metals.

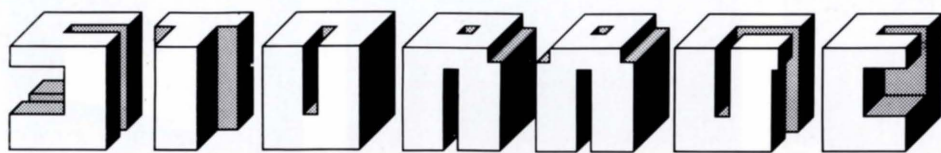
Pennies for bags.

Dollars for cans.

The change we could afford to make.







# HOW GOOD HOW LONG?

D. K. SALUNKHE, S. K. SATHE,  
and C. A. ERNSTROM

SCIENTIFIC STUDIES of long-term storage of foods are vital to insure optimum manufacturing, transporting, and storing procedures. Such investigations help identify ways to minimize nutritional and other losses while extending the shelf-life of the foods. One of the few long-term storage studies on freeze-dehydrated foods has been completed at USU.

As energy costs continue to rise, freeze-dehydration may soon become a practicable reality for processing many foods. Solar dehydration is a similarly promising technology for preserving foods in the future. Canning in polyethylene-type films which can withstand 250°F at 10 PSI may soon substitute for the tin cans. Considering the soaring prices asked for steel and tin, and the dangers of lead solder, the polyethylene-type containers soon may be judged economical and practical.

But, however foods are processed and packaged, the main question for consumers is: How long will they stay nutritionally worth eating and retain their taste?

## HEAT PROCESSED FOODS IN FLEXIBLE POUCHES

How long processed foods will remain acceptable and nutritionally adequate is important to all who manufacture, transport, store, or use them. As new and modified preservation techniques are introduced, the quality of foods subjected to these processes needs re-evaluation under various storage conditions. The interrelationships among storage time, temperature, humidity, and appearance affect consumer acceptance of a food and must be scientifically tested.

The storage-life of processed foods depends on factors such as type of product, method of processing, manner of packaging, and temperature and humidity during storage. All of these factors influence flavor, aroma, color, texture, and nutrient retention; which in turn, affect consumer acceptance of the food product. Each food has a certain storage potential under ideal conditions. However, the ideal is rarely attainable.

## Materials and methods

Eight items—ham and chicken loaf, beef steak, beef stew, frankfurters, fruit cake, pineapple, chocolate brownies, and cheese spreads were prepared by heat processing and packed in flexible pouches by an industrial manufacturer according to U.S. Army specifications.

Nutritional and organoleptic (taste panel) evaluations of the food samples were made as described elsewhere (Salunkhe, D. K., M. T. Wu, J. Y. Do, and J. W. Giffe 1978. *J. Food Quality* 2:75-103).

## Results and discussion

The results of the taste panel evaluations (Figures 1-8) and nutritional quality assessments (Table 1) indicated that all the heat-processed food products were in acceptable condition for up to 54 months of storage in their flexible pouches. The optimum storage temperatures for individual products did, however, differ. (In all cases, the 100°F storage temperature was most detrimental to quality.) The vitamin retention values (compared to the original vitamin contents of the samples) are shown in Table 1 and indicate that retention depended on both temperature and type of product. Niacin (being heat

stable) losses were least among the vitamins studied. In general, low temperatures during storage helped maintain nutritional quality. The taste panel evaluations of quality had similar trends, i.e. less deterioration at the lower (40° or 70°F) temperatures.

## FREEZE-DEHYDRATED FOODS

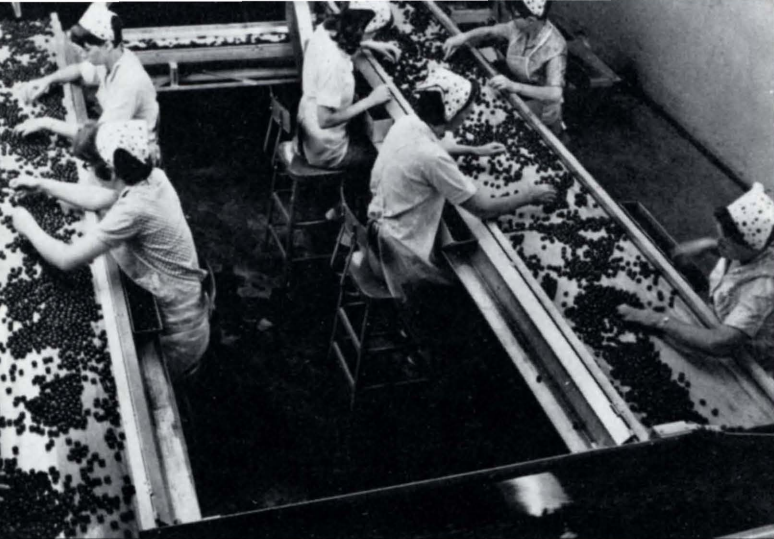
When freeze-dehydrated, high moisture foods retain many of their fresh food flavor components and require minimal time for reconstitution. The main advantage of freeze-dehydration is that more than 95 percent of the moisture of a food can be removed by sublimation under vacuum and low temperature, which preserves the original color, texture, and nutritive value of the food. The resulting porous, dried substance reabsorbs water rapidly when being prepared for consumption. The disadvantage is high cost.

Freeze-dehydration also may decrease the rates at which biochemical, enzymatic, and microbiological deterioration occur during subsequent storage. Discoloration may still occur, however, if the dehydrated products are stored under high temperature and high humidity conditions.

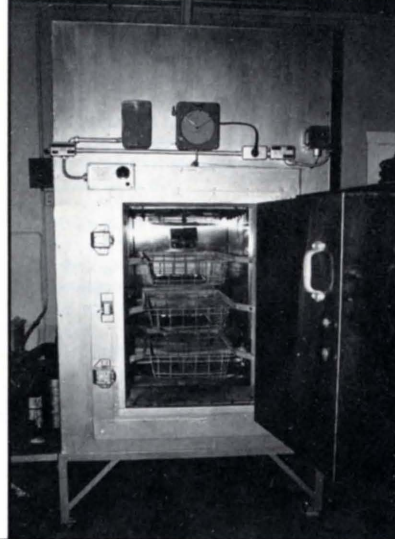
Along with their other qualities, freeze-dehydrated foods also retain much of their original size and shape. Compression is therefore used to alleviate the problems of brittleness and friableness during transportation, as well as to decrease packaging costs.

One of the few studies on how long-term storage affects the quality of freeze-dehydrated, compressed foods was completed at USU in our laboratories.

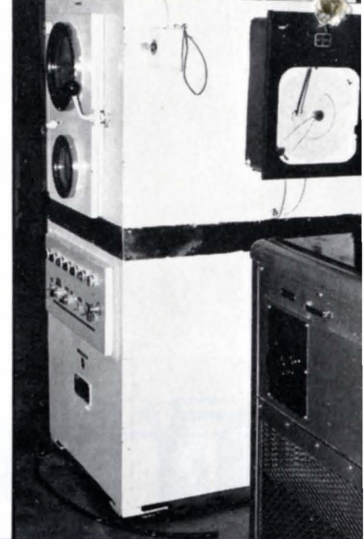




1



2



### Materials and methods

Eight freeze-dehydrated items (chicken stew, chicken with rice, beef hash, pork with escalloped potatoes, chili con carne with beans, beef stew, beef and rice, and spaghetti with meat sauce) were prepared and vacuum packed in double flexible pouches by a commercial manufacturer according to U.S. Army specifications. Nutritional and taste panel evaluations were performed as described elsewhere (Salunkhe, D. K., M. T. Wu, J. Y. Do, and J. W. Giffe 1978. *J. Food Quality* 2:75-103).

### Results and discussion

The results of the nutritional assessments are shown in Table 1. The taste panel evaluations (Figures 9-16) indicated that the products were acceptable for up to 44 months. Vitamin retention during this period of storage at 100°F ranged from 73.8 to 96.6 percent and reflected an interaction between type of product and temperature. Storage at lower temperatures (70° and 40°F) resulted in significantly better vitamin retention than storage at 100°F.

### FREEZE-DEHYDRATED COMPRESSED FOODS

Freeze-dehydrated fruits and vegetables are shelf-stable, light in weight, and maintain appetizing color and flavor. Their disadvantage of very low density (high volume per unit mass) can be overcome by compression. Such a reduction in volume gives ready mobility without weight. Additional advantages include small packages

(hence low cost of packaging materials), less packaging materials to dispose of, and reduced transportation costs as well as storage space requirements.

Freeze-dried fruits and vegetables such as cherries and green beans have been compressed and subsequently restored to their normal shape, volume, and texture through rehydration.

### Materials and methods

The methods used to produce compressed sour cherries have been described in detail elsewhere (J. Y. Do, C. Srisangnam, D. K. Salunkhe, and A. R. Rahman 1975. *J. Food Technol.* 10:191-201).

### Results and discussion

Freeze-dehydrated compressed cherries were also studied for their storage stability. The cherries maintained acceptable quality at 70° and 100°F for 12 and 6 months, respectively. Retention of both color and vitamin C content were promoted by sulphiting procedures.

### SOLAR DEHYDRATION OF FOODS

Heat from the sun has been used since antiquity to dry foods such as fruits, vegetables, and meat, milk, and milk products. Use of natural gas for hot air drying may be restricted in the future. Since many fruits are grown and harvested in hot, sunny geographic areas during the time of the year when solar radiation is abundant, solar dehydration appears an attractive alternative.

Although the total solar energy reaching the earth far exceeds human needs, this energy is in a "dilute" form. Collectors that harness and concentrate such energy must have a maximum heat absorption capacity. For food dehydration, some medium is also needed to carry the collected energy to a location where it can be applied. Air is an inexpensive, nontoxic carrier that can also remove moisture from the food. Unfortunately, air is a bad conductor of heat.

Solar dehydration of grapes and prunes would take less time than the conventional sun drying. For raisins, solar dehydration has also increased the retention of SO<sub>2</sub> as well as of vitamins (Bolin, H. R., personal communication).

A cooperative research in this area is in the planning stage with Dr. H. R. Bolin, Western Utilization Research Center, USDA, Berkeley California.

### ACKNOWLEDGMENTS

We gratefully acknowledge the U.S. Army for their support and several graduate and post-doctoral students for their technical help.

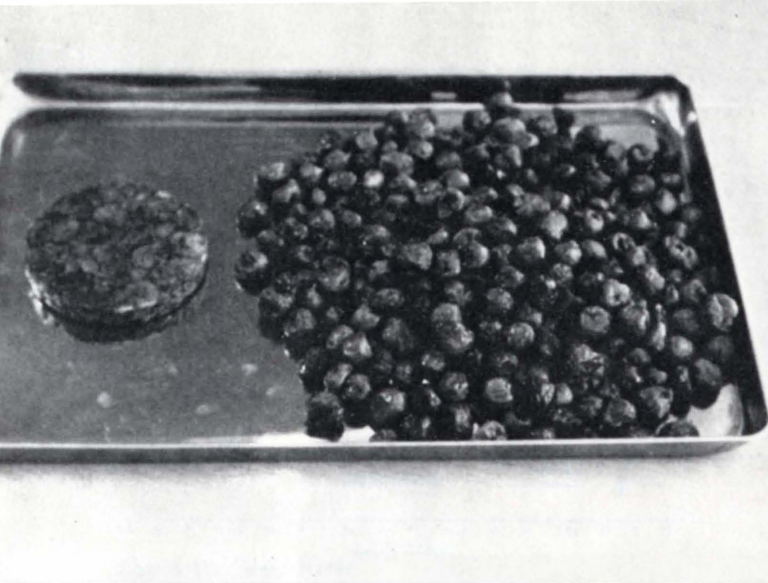
### ABOUT THE AUTHORS

D. K. Salunkhe is a Professor in the Department of Nutrition and Food Sciences.

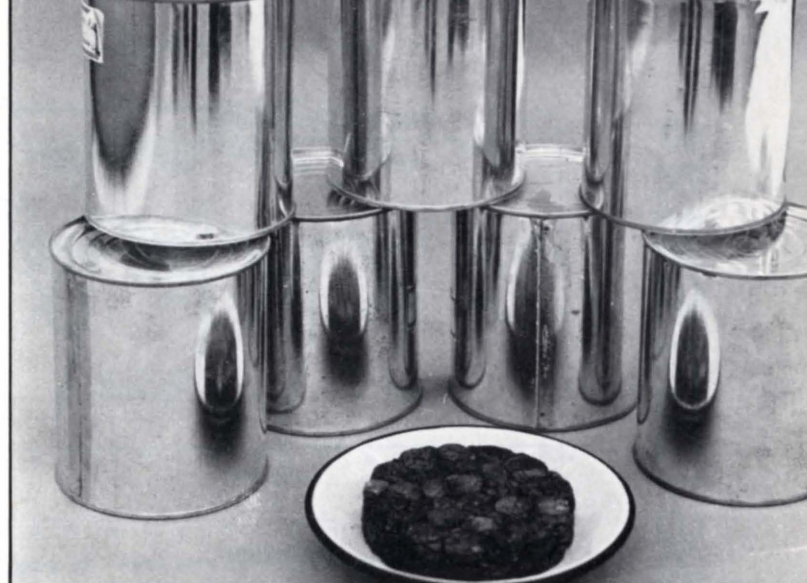
S. K. Sathe is a graduate student in the Department of Nutrition and Food Sciences, working toward his PhD.

C. A. Ernstrom is Department Head and Professor in the Department of Nutrition and Food Sciences.





4



5

**Figure 1.**  
Selecting perfect raw materials such as these cherries is the beginning of processing quality foods.

**Figure 2.**  
Blast freezer solidifies water in the food prior to freeze dehydration.

**Figure 3.**  
Freeze dehydration sublimates ice in food under vacuum and yields the dried product ready to package.

**Figure 4.**  
The number of cherries on the right is compressed into the disk on the left. With rehydration, the cherries are returned to their original volume.

**Figure 5.**  
This freeze-dried and compressed cake of sour cherries contains the same number of cherries as the seven cans behind it. The storage efficiency of this process is unparalleled.

**Figure 6.**  
Heat processed food such as these in the two bags, when reconstituted, will be the same volume of food as in five cans.

**Figure 7.**  
Frankfurters to chocolate brownies are heat processed, packaged, and stored 54 months successfully.

**Table 1. Storage stability and vitamin retention (%) of foods\***

Product	Processing and packaging	Acceptable shelf-life at		Vitamin retention (%) corresponding to acceptable shelf-life			
		Months	Temperature °F	B <sub>1</sub>	B <sub>2</sub>	Niacin	Vitamin C
Ham and chicken loaf	HEAT-PROCESSED FLEXIBLE POUCH	54	100	21.9	51.5	88.9	—
Frankfurters		54	70	52.3	72.8	93.4	—
Beef steak		54	100	43.9	75.0	87.7	—
Beef stew		54	40	88.5	93.5	95.5	—
Cheese spread		54	40	92.9	96.7	—	—
Pineapple		54	70	—	—	—	66.4
Fruit cake		54	70	73.5	81.3	94.6	—
Chocolate brownies		54	70	70.1	88.0	95.0	—
Chicken stew	FREEZE-DEHYDRATED	44	100	83.8	85.3	96.6	—
Chicken and rice		44	100	87.8	82.6	94.7	—
Beef hash		44	100	87.3	81.1	96.1	—
Pork with scalloped potatoes		44	100	93.5	79.8	90.2	—
Chili con carne with beans		44	100	82.4	73.8	94.3	—
Beef stew		44	100	83.6	75.1	93.2	—
Beef and rice		44	100	92.9	86.5	95.7	—
Spaghetti with meat sauce		44	100	82.7	77.3	94.4	—

\*Note: The products were stored at three temperatures (40, 70, and 100°F) and the stability under most adverse conditions is reported in this table.



6





Figure 1. Ham and Chicken Loaf

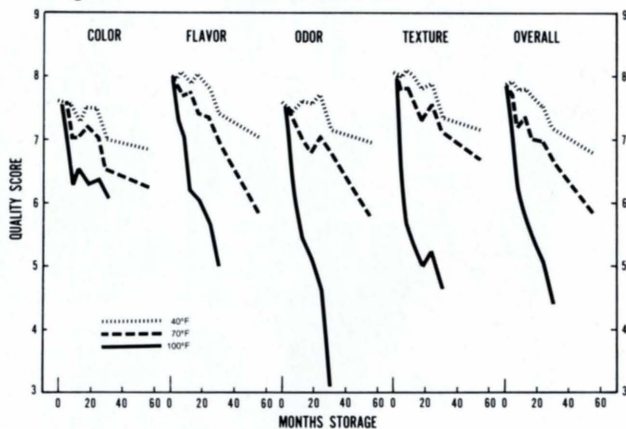


Figure 2. Frankfurters

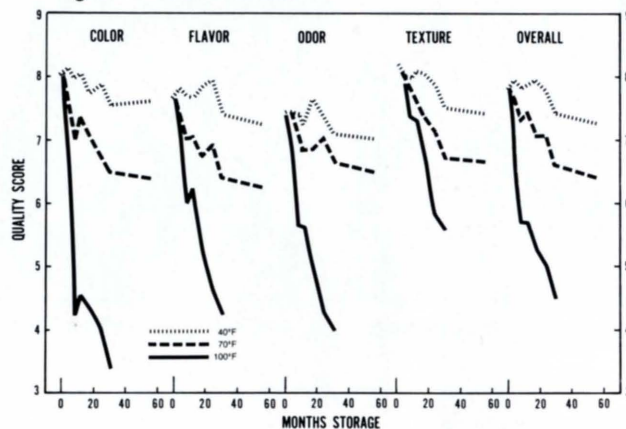


Figure 3. Beef Steak

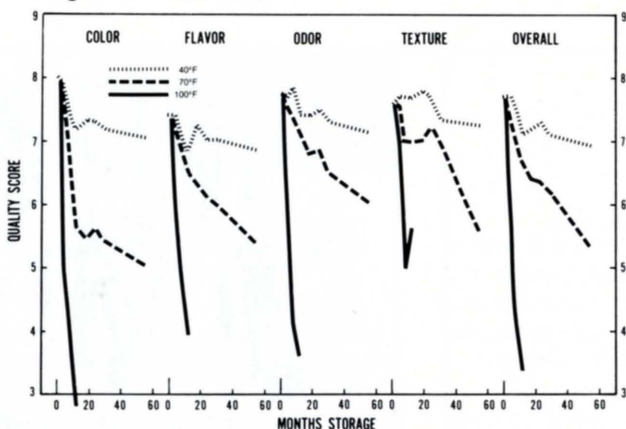


Figure 4. Beef Stew

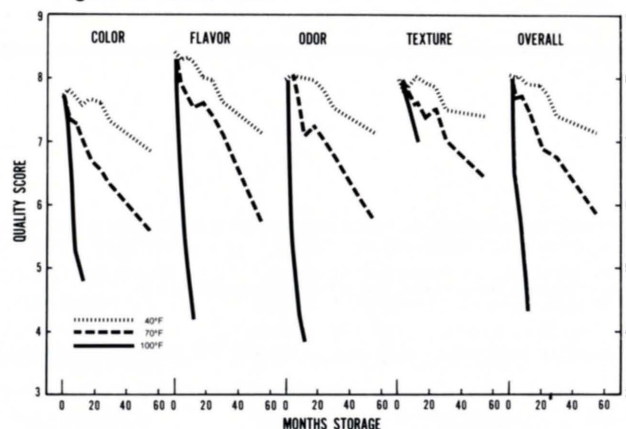


Figure 5. Cheese Spread

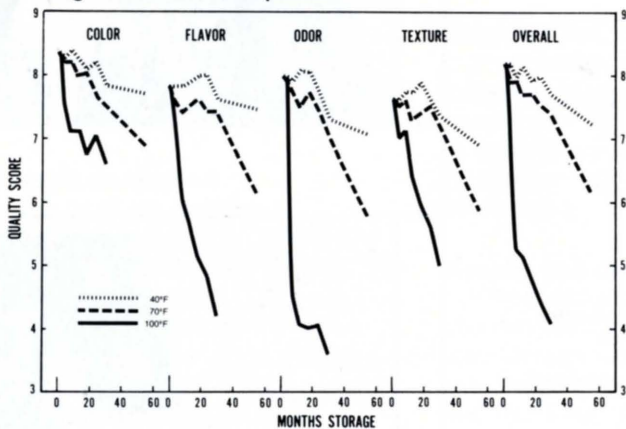


Figure 6. Pineapple

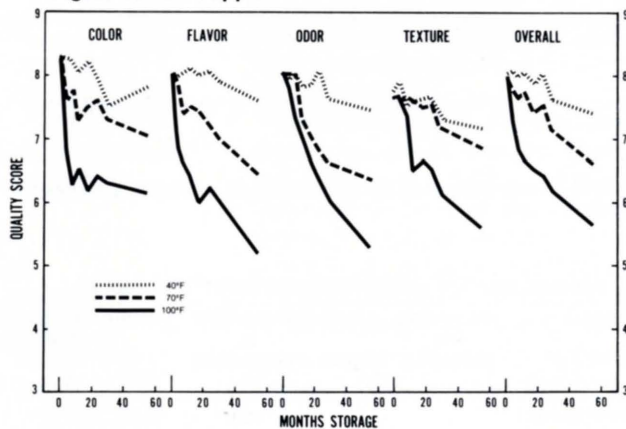


Figure 7. Fruitcake

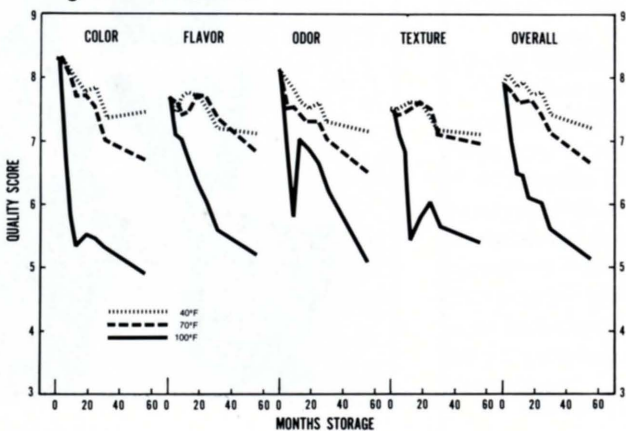
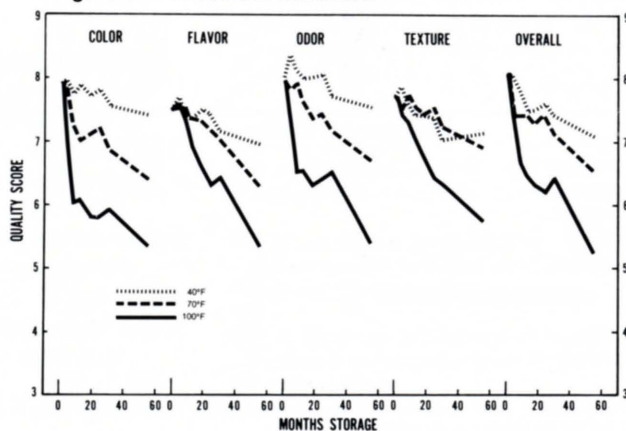
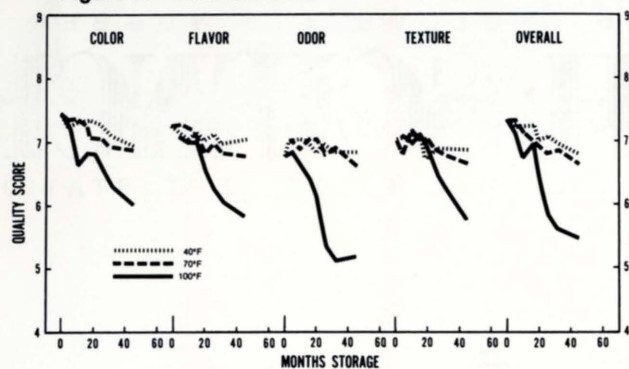


Figure 8. Chocolate Brownies

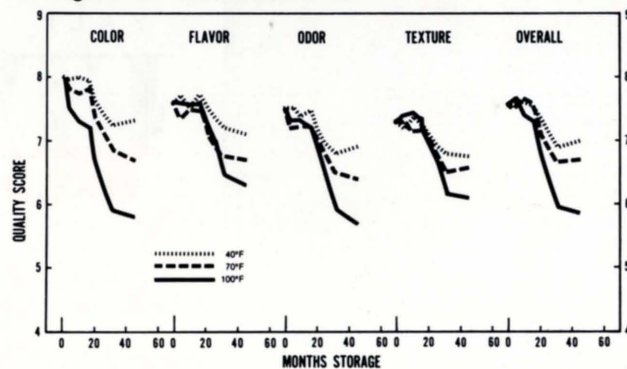




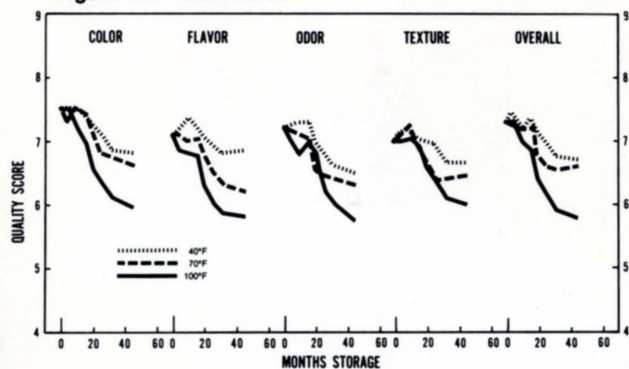
**Figure 9. Chicken Stew**



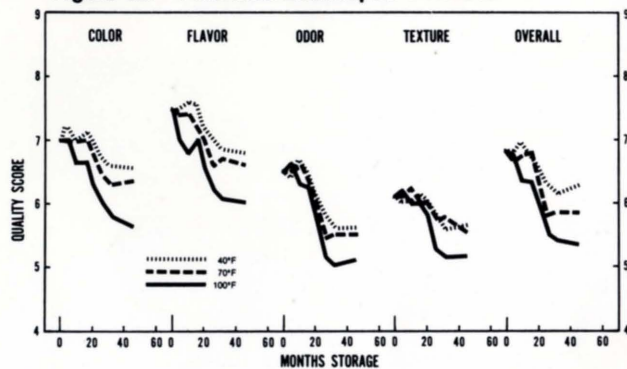
**Figure 10. Chicken and Rice**



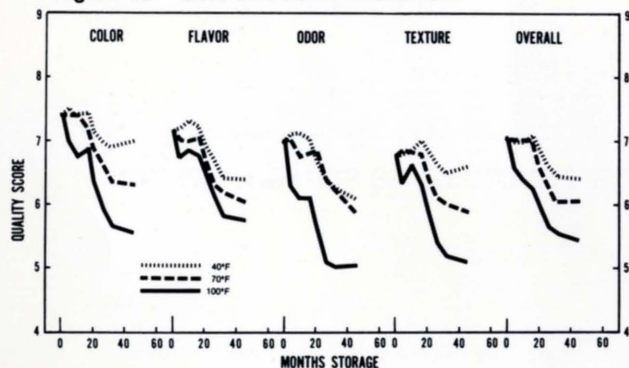
**Figure 11. Beef Hash**



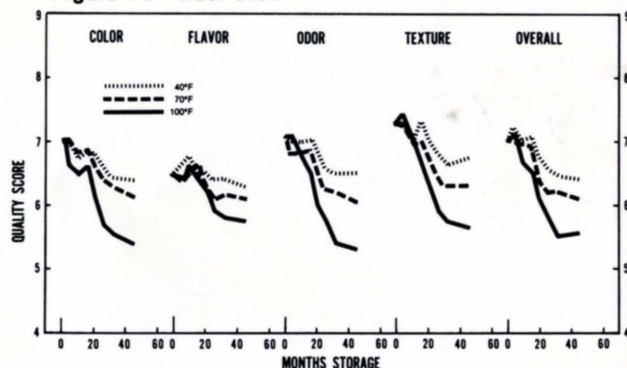
**Figure 12. Pork with Escaloped Potatoes**



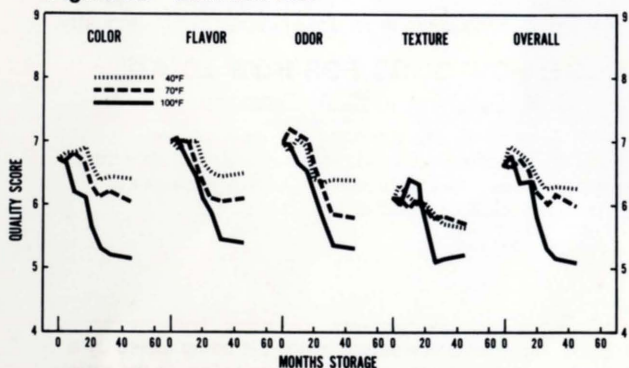
**Figure 13. Chili con Carne with Beans**



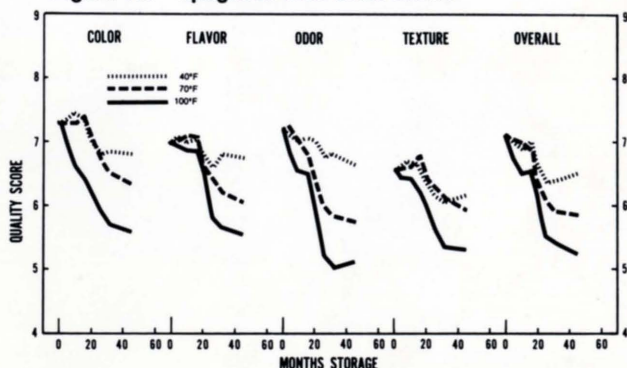
**Figure 14. Beef Stew**



**Figure 15. Beef and Rice**



**Figure 16. Spaghetti with Meat Sauce**





# UTAH SCIENCE

Agricultural Experiment Station

UTAH STATE UNIVERSITY  
LOGAN, UTAH 84322

*Doyle J. Matthews*  
DIRECTOR

Address Correction Requested



POSTAGE PAID  
U.S. DEPARTMENT  
OF AGRICULTURE  
AGRI 101

UTAH SCIENCE is a quarterly devoted to research in agriculture, land and water resources, home and community life, human nutrition and development, and other wide-ranging research conducted at Utah State University. Published by the Agricultural Experiment Station, Utah State University, Logan, Utah 84322.

The magazine will be sent free on request. Please include a mailing label from a recent issue of UTAH SCIENCE with any request for change of address.

To avoid overuse of technical terms, trade names of products or equipment are sometimes used. No endorsement of specific products or firms named is intended, nor is criticism implied of those not mentioned.

Articles and information appearing in UTAH SCIENCE become public property upon publication. They may be reprinted provided that no endorsement of a specific commercial product or firm is stated or implied in so doing. Please credit the authors, Utah State University, and UTAH SCIENCE.

Stanford Cazier  
President  
Utah State University

Doyle J. Matthews  
Director  
Agricultural Experiment Station

C. Elmer Clark  
Associate Director  
Agricultural Experiment Station

Karen Kreutzer Kleinschuster  
Editor

Lois M. Cox  
Science Writer

Carol Grundmann  
Graphic Designer and Photographer

Anne E. Ferguson  
Editorial Assistant

Mike Jackson  
Distributor and Photographer

Don Carter  
Technical Assistant

"Utah State University is committed to a policy of equal opportunity in student admission, student financial assistance, and faculty and staff employment and advancement, without regard to race, color, religion, sex, age, national origin, or handicap."